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This report presents a review of ten years of aircraft maintenance data and its effects on mathematical modeling. A Maintainability Index Model (MIM) was previously developed using 3-M data from the 1975/1976 time period. Since then, maintenance data for the aircraft used to develop the MIM has increased resulting in the model under predicting current year data by 40% and life cycle data by 18%. Because of the variability and instability of 3-M data, a recommendation is made to update the model annually on an interim

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basis through the use of Maintenance Inflation Factors and to provide a complete update of the MIM data base every five years.

PREFACE

This final Technical Report on a review of the Maintainability Index Model historical data base was prepared by the Maintainability Engineering Group of the Vought Corporation, Dallas, Texas under Contract No. N00140-79-C-0445 for Naval Air Systems Command, Washington, D.C. The objective of this study was to conduct a review of current Navy 3-M data and recommend the most efficient and cost effective method for model update. Variations among current year data, life cycle data and the existing model data base were to be noted.

This project was conducted under the technical cognizance of Mr. George J. Donovan and Mr. Carl Tanger, Airframe and Equipment Branch, AIR-4114.

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SUMMARY

Introduction

A Maintainability Index Model (MIM) was developed in 1978 to assist the Navy in establishing maintainability requirements and in evaluating contractor predictions for notional Navy fighter, attack and anti-submarine warfare (ASW) aircraft during conceptual and development design. The model used historical, Navy 3-M maintenance data from the 1975/1976 time period to functionally relate aircraft maintenance characteristics to design and performance parameters. In the time since the MIM was developed, aircraft maintenance data has increased resulting in the model under predicting new aircraft maintenance requirements.

A review of historical 3-M data was made to determine the most efficient and cost effective method for model update. System level maintenance experience for the aircraft used in the MIM was investigated from first year of operation through the latest current year data available. The existing model data base was compared with current and life cycle data bases and a procedure for model updating was established.

Results

The intent of the MIM was to determine aircraft maintenance requirements for a notional aircraft in an operational environment when it had reached maturity. Analysis of ten years of 3-M data showed aircraft maintenance expenditures steadily increasing with time driving the mature or life cycle

data average higher and higher. As a result, estimating relationships for determining Maintenance Manhour per Flight Hour (MMH/FH) values showed predicted values to be 40% below current year (1979) data and 18% below life cycle data.

Analysis showed that the A-4M which once required 3.2 unscheduled MMH/FH during its first year of operation, now requires two and a half times that value. The AV-8A, a relatively small aircraft, now requires a higher MMH/FH than the more complex and heavier A-7E and S-3A. The A-6E which once averaged 32.5 MMH/FH during its first four years of operation now averages 44.2.

Conclusions

As a result of this study, it is recommended that the Maintainability Index Model be updated on an annual interim basis through the use of Maintenance Inflation Factors (MIF) and that the complete MIM data base be updated every five years.

This study shows that current year data is not representative of the last ten years of aircraft maintenance data. Current year data or any annual data base is too unstable to warrant a complete model update every year. Updating the MIM to current year data will result in a model that over predicts life cycle data and would not be representative of a mature aircraft. Interim and complete model update should be to the latest life cycle data.

The use of Maintenance Inflation Factors offers an attractive alternative to a complete annual model data base update. Not only is the use of MIF's cost effective, but updating can be accomplished using the MIM computer program

just by inputting revised inflation factors. Validation showed MIF's do not degrade model output.

MAINTAINABILITY INDEX MODEL DATA BASE STUDY

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1.0 INTRODUCTION

1.1 OBJECTIVE OF STUDY

The objective of this study was to conduct a review of 3-M data by calendar year and recommend the most efficient and cost effective method for update of the Maintainability Index Model (MIM). Variations among current year data, life cycle data, the existing MIM data base and model output were to be noted.

1.2 HISTORICAL BACKGROUND

Under an earlier contract from NAVAIR, reference (1), Vought Corporation developed a model for predicting maintainability characteristics of notional Navy fighter, attack and ASW aircraft. The MIM used historical data on eight Navy aircraft to functionally relate aircraft maintenance characteristics to design and performance parameters. The historical maintenance data base consisted of 4 to 12 months of 3-M data from the 1975/1976 time period for the A-4M, A-6E, A-7E, AV-8A, F-4J, F-8J, F-14A and S-3A aircraft. Regression analysis techniques were used to relate historical maintenance data at the two-digit Work Unit Code (WUC) level to aircraft design characteristics. Each maintainability prediction equation consisted of one or two aircraft characteristics as independent variables.

In the three years following the MIM development, aircraft maintenance expenditures for the aircraft used in the MIM have increased to the point of seriously affecting the model output. As a result, a review of the MIM data base was necessary.

1.3 GENERAL APPROACH

The approach taken to satisfy the study objective was as follows:

- Collect and analyze life cycle 3-M data for the eight aircraft used in the initial study.
- Investigate system and weapons system level maintenance experience on a calendar year basis from first year of operation through the latest current year data available.
- Compare the 3-M data base used to develop the MIM with current and life cycle data bases.
- Discuss the impact current and life cycle data have on the model output.
- Recommend a procedure for model update.

2.0 DATA BASE COMPARISON

2.1 EXISTING MODEL DATA BASE

A 4 to 12 month 3-M data base was originally selected for use in the model development (Table 1). Raw 3-M data tapes were processed by Vought computer routines into a series of reports depicting unscheduled maintenance, scheduled maintenance and support actions. Outputs from those reports were converted to a Standard Work Unit Code (SWUC) and used to develop maintainability prediction equations.

TABLE 1. MIM DATA BASE

AIRCRAFT	TIME PERIOD	MONTHS	FLT HRS
A-4M	DEC 75 - MAR 76	4	7,160
A-6E	DEC 75 - MAR 76	4	19,802
A-7E	JAN 75 - DEC 75	12	106,225
AV-8A	DEC 75 - MAR 76	4	5,944
F-4J	DEC 75 - MAR 76	4	26,238
F-8J	JAN 73 - AUG 73	8	14,087
F-14A	DEC 75 - APR 76	5	12,133
S-3A	JAN 75 - DEC 75	12	22,820

Source: Raw 3-M data tapes

To verify that the 4 to 12 month data base was representative of mature aircraft in an operational environment, a correlation test was performed which compared the MIM data base with a larger six year life cycle data base. Figure 1 shows such a comparison for total aircraft MMH/FH. Life cycle data available at that time was from July 1970 through December 1976.

Model validation was made at both the system and weapons system level. Most systems exhibited correlation coefficient's in the high 90's indicating excellent data correlation (See reference 1). Total weapons system validation is shown in Figure 2. Results showed good correlation between actual and calculated data with the model slightly under predicting baseline aircraft maintenance by about 8%. The slight under prediction was the result of the ground rules established for system regression analysis.

The existing model data base was representative of then year life cycle data and provided good correlation with calculated data. Since this study's objective is concerned with updating that data base, it is necessary to evaluate current year data and life cycle data.

2.2 CURRENT YEAR DATA

Analysis of current year (1979) 3-M data indicates that aircraft MMH/FH has increased an average of 31% over the MIM data base (Table 2). Various reasons are the cause of this including aircraft growth and the continued trend of equipment wear out. Two additional factors were the fuel shortage in 1979 and the increased demand on improving aircraft readiness. A cut back in fuel expenditures decreased aircraft utilization reducing flying hours but there was not a proportional reduction in maintenance manhours. The aircraft still had to be maintained regardless of the utilization rate. Improving aircraft readiness resulted in more manhours being expended for deferred maintenance to make downed aircraft operationally ready.

TABLE 2. TOTAL AIRCRAFT MMH/FH COMPARISON

AIRCRAFT	MIM DATA BASE (1)	CURRENT YEAR DATA (2)	NET CHANGE (%)
A-4M	14.8	19.5	+32
A-6E	29.7	44.2	+49
A-7E	25.0	33.5	+34
AV-8A	23.1	37.9	+64
F-4J	40.7	52.5	+29
F-8J	35.3	34.7(3)	- 2
F-14A	52.2	57.8	+11
S-3A	28.0	37.3	+33
			+31

(1) Reference 1
(2) 3-M Data from MSOD 4190.A2092-1 for Jan 79 - Sep 79.
(3) Jan 75 - Dec 75 Data, F-8J phased out of service in 1976.

With current year maintenance data substantially above the values used in the MIM data base, the next step was to compare model predictions to current year data to check if the same relationship held true. Figure 3 shows that the model output (predictions) becomes unrealistic when compared to current year data. In order to bring the model back in line, it was decided to bias the model with Maintenance Inflation Factors (MIF). Figure 4 shows that increasing the MIM calculated total aircraft MMH/FH value for each aircraft by 40% provided good correlation with current year data. (In actuality, a MIF is determined for each of the 32 systems that comprise the weapons system with the weighted average approximating 40%.)

2.3 LIFE CYCLE DATA

The intent of the Maintainability Index Model is to determine the average maintenance requirements for notional aircraft in an operational environment.

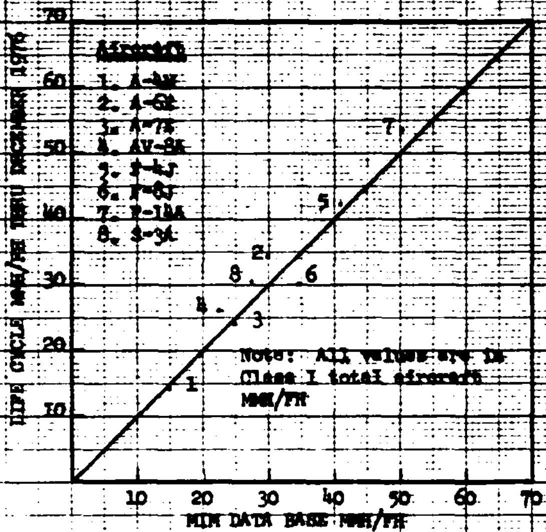

FIGURE 1. MIM DATA BASE VERIFICATION

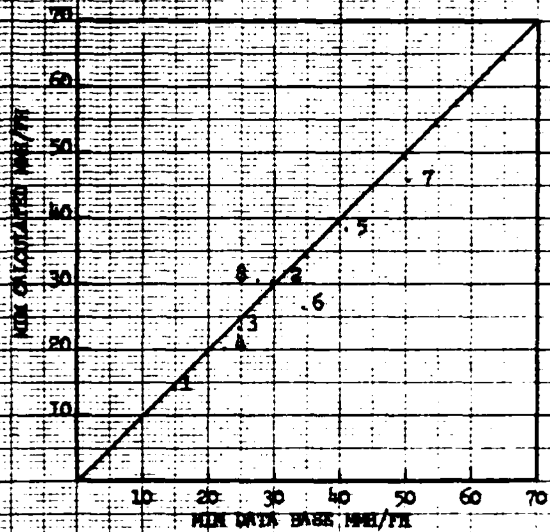

FIGURE 2. MODEL VALIDATION

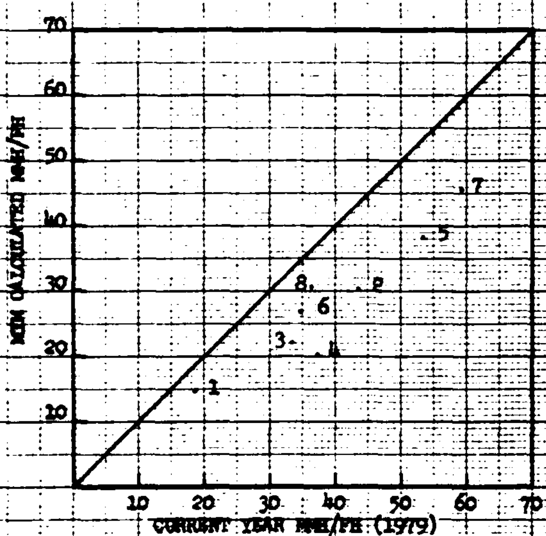

FIGURE 3. MODEL OUTPUT VERSUS CURRENT YEAR DATA

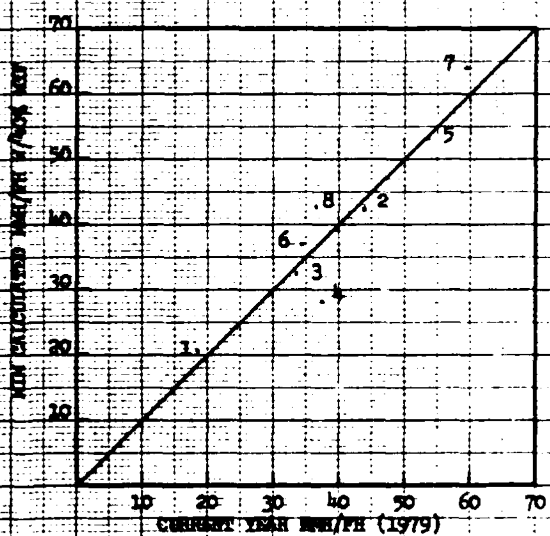

FIGURE 4. MODEL OUTPUT ADJUSTED FOR MAINTENANCE INFLATION TO CURRENT YEAR AVERAGE

The previous discussion indicated that the average maintenance requirements on which the MIM is based have increased substantially in 1979. To determine how this increase and any increases in other years since MIM development may have affected the MIM predictions, life cycle data from July 1970 through September 1979 of each aircraft was analyzed.

Figure 5 shows that life cycle data is higher than the existing MIM data base. As in the case of current year data, this has resulted in the model under predicting total aircraft MMH/FH, Figure 6. By biasing each aircraft's predicted total aircraft MMH/FH value by 18%, Figure 7, the model can be brought back in line with life cycle data. This biasing or Maintenance Inflation Factor is the result of a weighted average as calculated for each system.

2.4 DATA BASE COMPARISON CONCLUSIONS

Updating the model to current year data will only distort the model output. Current year data is not representative of life cycle data as shown by Figure 8. It is currently running about 19% higher than life cycle data.

Based on this analysis, the model should be revised to reflect the latest life cycle data rather than the latest current year data. Current year data or any annual data base changes too rapidly from year to year to warrant a complete model update every year. Life cycle data does not change as rapidly from one year to the next because of its large data base. As a result, the use of Maintenance Inflation Factors offer an attractive alternative for an interim MIM update.

A more detailed discussion on aircraft maintenance data and model update rationale follows.

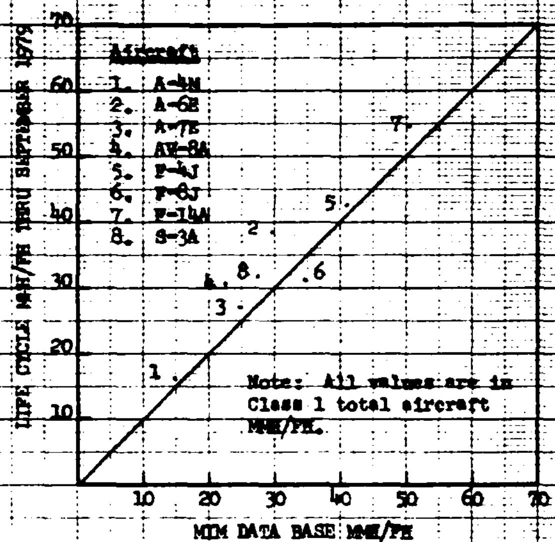

FIGURE 5. DATA BASE COMPARISON

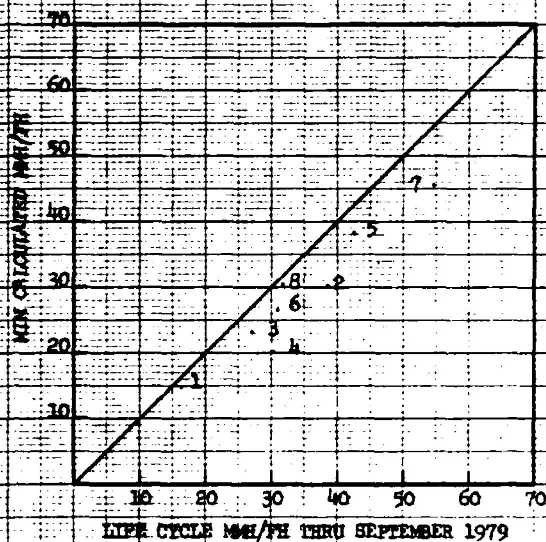

FIGURE 6. MODEL OUTPUT VERSUS LIFE CYCLE DATA

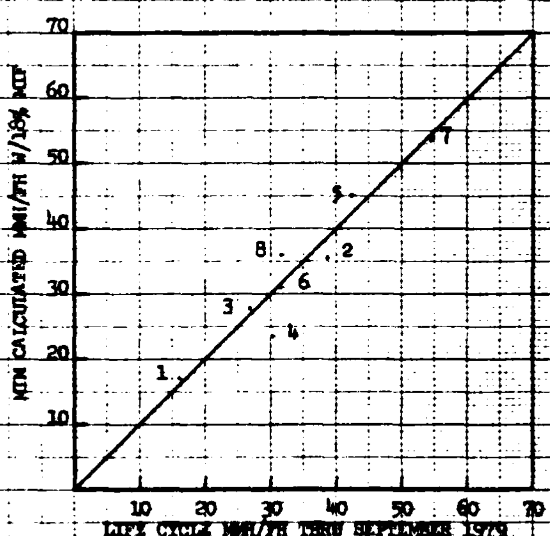

FIGURE 7. MODEL OUTPUT ADJUSTED FOR MAINTENANCE INFLATION TO LIFE CYCLE AVERAGE

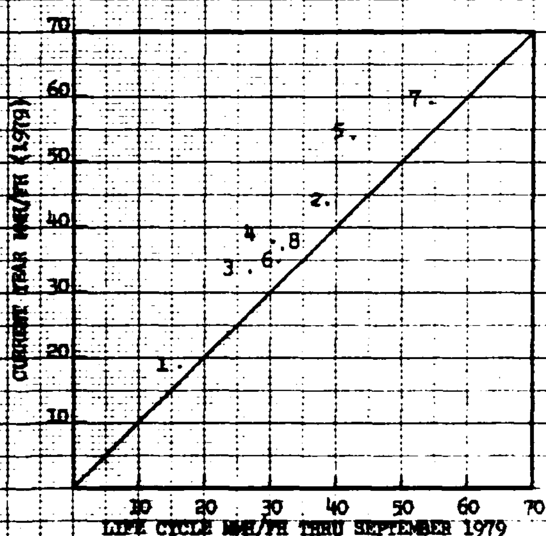

FIGURE 8. CURRENT YEAR VERSUS LIFE CYCLE DATA

3.0 TEN YEARS OF AIRCRAFT MAINTENANCE DATA

Appendix E to the Aircraft Maintenance Experience Design Handbook (reference 1) discussed some of the factors which affect weapons system maintenance requirements. One such factor is that MMH/FH does not remain constant for a given aircraft but instead varies significantly with time. Analysis showed that the series A-model of an aircraft such as the F-14A and S-3A tend to follow a modified "bathtub" curve as depicted in Figure 9.

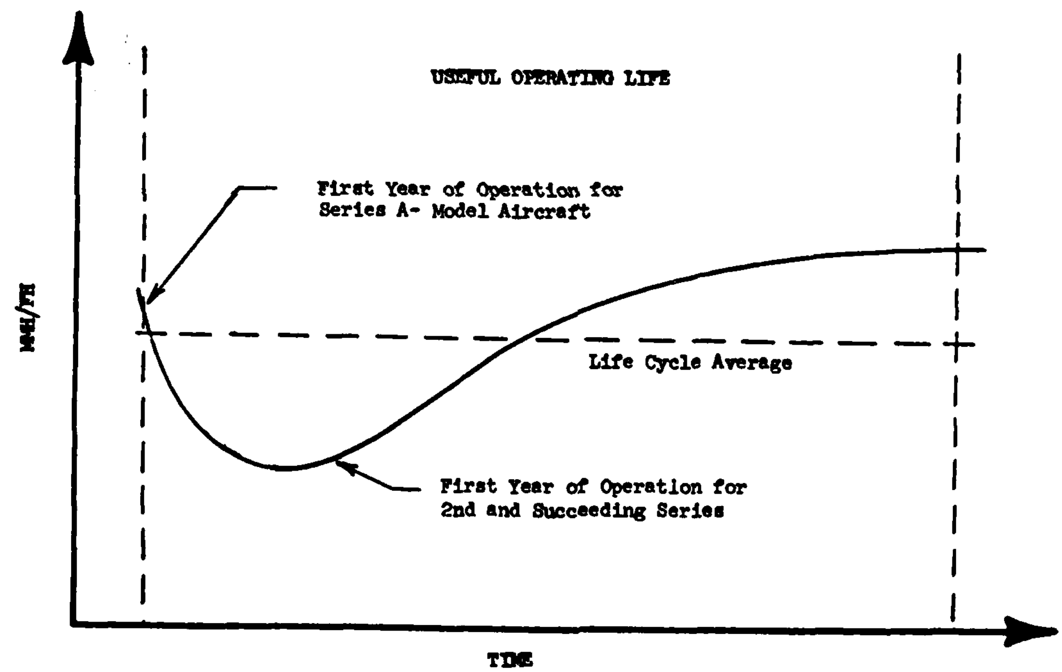

Figure 9 Actual "Bathtub" Curve

Second and succeeding series of an aircraft such as the A-4M, A-7E and F-4J start off at the low point in the curve and continue to increase. These aircraft normally do not exhibit the new aircraft problems to the degree their series A-model predecessors did. The steady increase in MMH/FH is primarily attributed to aircraft maintenance problems and equipment wear out. It is this

change in maintenance with time and its impact on the Maintainability Index Model that will be addressed in this section.

3.1 DATA COLLECTION

The approach taken for this study was to collect and analyze life cycle 3-M data for the A-4M, A-6E, A-7E, AV-8A, F-4J, F-8J, F-14A and S-3A aircraft. Data sources selected were two periodical 3-M aviation information reports published by the Naval Maintenance Support Office Mechanicsburg, Pennsylvania:

(a) Fleet Weapon System Reliability and Maintainability Statistical Summary Tabulation, MSOD 4790.A2142-01, July 1970 through September 1979, (Reference 2).

(b) Monthly 3-M Aviation Readiness Utilization Summary, MSOD 4790.A2092-01, July 1970 through September 1979, (Reference 3).

Monthly, quarterly and/or semi-annual data were extracted from these documents and programmed into a Fleet Reliability and Maintainability Summary (FRAMS) report excerpts of which are presented as Appendices A and B. Data was collected at both the system and weapons system level.

Reference (2) provided unscheduled maintenance data at the system level. A total of 24 microfilm/microfiche reports covering ten years of data were used. From each report the following data was extracted by two-digit WUC for each aircraft:

- Total flight hours
- Total maintenance actions
- Unscheduled maintenance manhours (O and I-level combined)

Reference (3) was used to provide total aircraft MMH/FH data. This value included scheduled maintenance and support as well as unscheduled maintenance. A total of 20 monthly reports were used to extract "Navy-wide, six-month average, actual DMMH/FH" values by aircraft type, model and series (T/M/S). A computer routine was written to calculate Maintenance Manhours per Flight Hour (MMH/FH) and Maintenance Actions per Flight Hour (MA/FH) for each aircraft by calendar year and Standard Work Unit Code (SWUC). MIM data base and MIM calculated MMH/FH and MA/FH values also were included.

As a result, the FRAMS report provided a comparison between 3-M data of different time periods and the existing MIM data base. Relationships between first year and current year data were noted along with comparisons between current year and life cycle data. Using this data, a series of Maintenance Inflation Factors were derived relating model output to different time periods.

3.2 AIRCRAFT MAINTENANCE HISTORY

A review of 10 years of 3-M data has shown the dynamic nature of aircraft maintenance. The A-4M which once required 3.2 unscheduled MMH/FH during its first years of operation, now requires two and a half times that value. The AV-8A, a relatively small aircraft, now requires a higher MMH/FH than the more complex and heavier A-7E and S-3A aircraft. The A-6E which once averaged 32.5 MMH/FH during its first four years of operation now averages 44.2.

The eight T/M/S aircraft used to develop the MIM were selected because they represented the latest in design technology and they possessed the range and variation in design characteristics necessary to produce valid estimating relationships. Five of these aircraft became operational in the 1970's and the

remainder entered service in the late 1960's (Table 3). During the decade of the 1970's, these eight T/M/S aircraft accumulated almost three million flight hours while requiring over 93 million manhours for maintenance and support. These two values do not tell the whole story for much needs to be said about the year to year trend in data and its impact on mathematical modeling. A discussion of the maintenance history on some of these aircraft follows based on FRAMS data presented in Tables 4 and 5.

TABLE 3. MILESTONE DATES

ACFT	FLIGHT	FIRST FLEET DELIVERY	FIRST YEAR OF 3-M DATA (1)	NO. YEARS OPERATIONAL	TOTAL FLIGHT HOURS (2)
A-4M	APR 1970	NOV 1970	1971	9	164,454
A-6E	FEB 1970	OCT 1971	1972	8	363,314
A-7E	NOV 1968	JUL 1969	1970	10	895,253
AV-8A	AUG 1966	JAN 1971	1972	8	83,767
F-4J	MAY 1966	DEC 1966	1970	14	715,915
F-8J	JAN 1968	JUL 1968	1970	8	89,299
F-14A	DEC 1970	OCT 1972	1973	7	220,973
S-3A	JAN 1972	FEB 1974	1974	6	229,058
					2,991,091

(1) Data prior to July 1970 not available.
(2) Total flight hours from July 1970 through September 1979 (reference 2).
Source: Jane's All the World's Aircraft

<u>A-4M</u>

The A-4M was delivered to the Navy on November 3, 1970. During its first year of operation, it averaged 3.2 unscheduled MMH/FH. Analysis of the 3-M data for succeeding years of operation shows A-4M system maintenance increasing to a current year (1979) value of 8.5 unscheduled MMH/FH. Aircraft growth has accounted for some of this increase but the main reason for the increase

TABLE 4. DATA BASE COMPARISON - UNSCHEDULED MMH/FH

AIRCRAFT	FIRST YEAR DATA	CURRENT YEAR DATA	LIFE CYCLE DATA	MIM DATA BASE	MIM CALCULATED
A-4M	3.24	8.46	6.08	5.55	5.95
A-6E	10.75	22.04	17.97	12.90	13.13
A-7E	5.74	13.52	10.82	10.29	10.05
AV-8A	12.18	17.87	13.18	8.67	6.60
F-4J	10.87	25.68	19.68	19.38	17.21
F-8J	10.16	16.05	13.84	13.74	10.81
F-14A	35.60	28.31	26.60	23.95	20.58
S-3A	15.18	17.31	15.16	13.14	15.35

(1) Data prior to July 1970 not available.
Source: Appendix A and Reference 1

TABLE 5. DATA BASE COMPARISON - TOTAL AIRCRAFT MMH/FH

AIRCRAFT	FIRST YEAR DATA	CURRENT YEAR DATA	LIFE CYCLE DATA	MIM DATA BASE	MIM CALCULATED
A-4M	13.9	19.5	16.3	14.8	14.6
A-6E	32.5	44.2	39.0	29.7	30.2
A-7E	17.6	33.5	27.1	25.0	23.2
AV-8A	24.5	37.9	30.6	23.1	20.0
F-4J	27.3	52.5	42.3	40.7	38.2
F-8J	27.0	34.7	31.1	35.3	26.4
F-14A	64.9	57.8	54.5	52.2	45.6
S-3A	29.6	37.3	32.2	28.0	30.5

in MMH/FH can be attributed to equipment wear out. The weighted life cycle average as measured over the nine years the aircraft has been operating was determined to be 6.1 unscheduled MMH/FH.

In summary, current year data has increased 161% over first year data while life cycle data has increased 88%. When prorated over nine years, this equates to an annual maintenance inflation rate of 12.6%. Similarly, total aircraft MMH/FH has increased from 13.9 for the first year of operation to 19.5 for 1979. The life cycle average was calculated to be 16.3 total aircraft MMH/FH.

The A-4M 3-M data base used to develop the MIM was from the December 1975 through March 1976 time period. MIM calculated total aircraft MMH/FH was determined to be 14.6 which was comparable to a MIM data base value of 14.8. When MIM calculated total aircraft MMH/FH was compared to a later data base, the model under predicted A-4M life cycle data by 12% and current year data by 34%. Systems showing the greatest increase since model development were bombing navigation, communications and flight reference. Reasons for this include the addition of new equipment and an increase in equipment failure rates.

<u>AV-8A</u>

The AV-8A entered service with the Marine Corps in January 1971 with 3-M data beginning the following year. Since then, total aircraft MMH/FH has been increasing at a rate of about 6% per year from 24.5 in 1972 to 37.9 in 1979. Life cycle data has averaged 30.6 which is about 8.0 MMH/FH above the MIM data base value. This indicates the MIM will under predict AV-8A life cycle data by 53% and current year data by 90%. Almost all systems have shown a substantial increase in maintenance since model development with airframe, electrical and

engine systems showing the largest gain. As a result, a re-evaluation of the AV-8A MIM data base is in order.

F-14A

The F-14A has followed a modified bathtub curve more closely than any aircraft. First year data showed the F-14A requiring 64.9 total aircraft MMH/FH. Initial program start-up problems were attributed to the lack of Ground Support Equipment (GSE), the training of personnel and high engine maintenance. For the second year of operation, maintenance dropped to 40.2 total aircraft MMH/FH. Since then it has increased annually to a 1979 value of 57.8. Mechanical and structural systems showed the largest increase over second year data: airframe up 94%, flight controls up 43%, engines up 41%. Avionic system maintenance remained about the same or showed a modest increase. The electrical system showed the largest increase, 204%. The net impact on the MIM is that it under predicts life cycle data by 20% and current year data by 28%.

Analysis showed the remaining aircraft followed a similar trend of increased maintenance expenditure with time.

3.3 SYSTEM MAINTENANCE TRENDS

To gain a better perspective on the behavior of aircraft maintenance data for use in mathematical modeling, it was necessary to investigate what happens at the system level. Study findings on selected systems are presented below.

Airframe/Fuselage System

Table 6 shows life cycle MMH/FH data by calendar year for the SWUC 11/12 (Airframe/Fuselage System). A general increase in MMH/FH as a function of time

is noted for all aircraft. Figure 10 shows the magnitude of this increase for selected aircraft.

TABLE 6. SWUC 11/12 $MMH_{O,I}$/FH BY AIRCRAFT AND CALENDAR YEAR

YEAR	A-4M	A-6E	A-7E	AV-8A	F-4J	F-8J	F-14A	S-3A
1970	.000	.000	.538	.000	1.035	1.121	.000	.000
1971	.172	.000	.727	.000	1.263	1.865	.000	.000
1972	.200	.749	.998	.743	1.487	1.773	.000	.000
1973	.265	1.234	1.247	.595	2.055	1.817	4.190	.000
1974	.393	1.456	1.170	.880	2.716	1.702	2.063	.970
1975	.453	1.430	1.197	.960	2.673	1.397	2.424	1.000
1976	.421	1.547	1.206	1.243	2.699	0.000	2.568	1.016
1977	.418	2.012	1.553	1.253	2.645	0.000	3.521	1.172
1978	.454	1.680	1.466	1.132	3.055	0.000	3.906	1.715
1979	.551	2.157	1.732	1.743	3.139	0.000	4.006	1.746
*LCD	.408	1.706	1.283	1.116	2.307	1.638	3.347	1.354

* Life Cycle Data

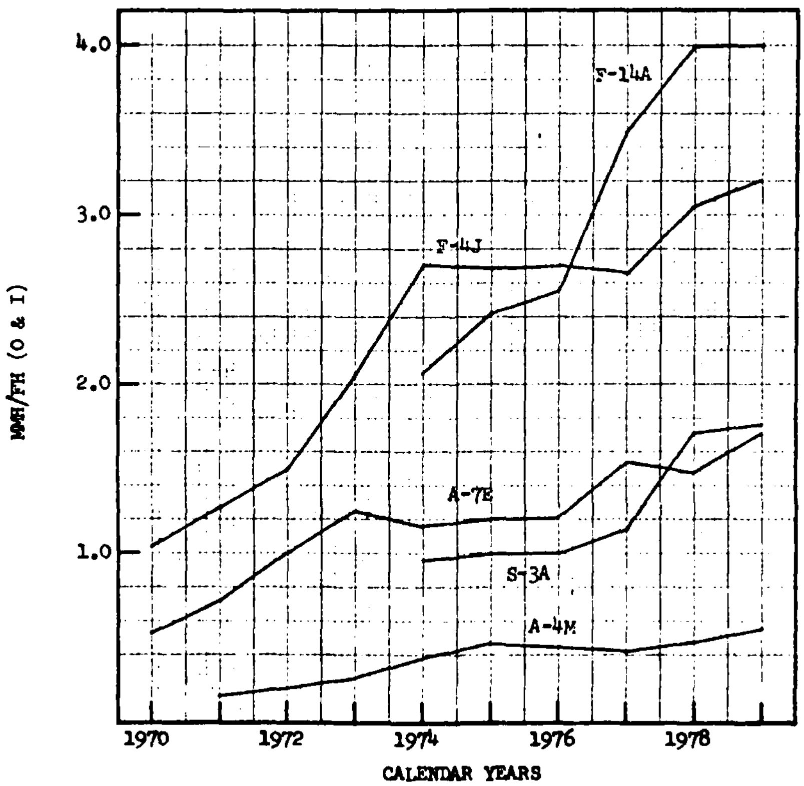

FIGURE 10. SWUC 11/12 AIRFRAME/FUSELAGE SYSTEM MMH/FH TRENDS

Analysis indicates the increasing trends shown in Figure 10 are primarily attributed to an increase in corrosion removal maintenance brought about by a higher maintenance rate (MA/FH) over previous years rather than an increase in average repair time. As aircraft age, more maintenance actions occur and a greater effort is required to control corrosion. Even the S-3A which had one of the best corrosion control design programs of any Navy aircraft in the fleet is now experiencing the same trend as other aircraft.

Electrical System

The Electrical System, SWUC 42, is another system which showed an increased maintenance trend with aircraft age. Continuing electrical wiring problems on the A-6E contributed to the sharp increase in MMH/FH as shown in Figure 11. A-6E electrical maintenance problems in 1976 were at the point where its 3-M data was no longer statistically valid in relation to its design parameters. Consequently, the A-6E was dropped from the electrical system portion of the MIM. Current year MMH/FH is double the 1976 value. Electrical wiring maintenance is also responsible for the F-14A MMH/FH trend. However, its maintenance expenditure is commensurate with its design characteristics. The S-3A, on the other hand, appears to have corrected its wiring problems through design and has maintained almost a constant maintenance rate over five years of operation.

Hydraulic System

Not all systems have deteriorated with equipment age. Figure 12 shows that SWUC 45 (Hydraulic System) maintenance for the most part has remained constant with time. Both the A-7E and S-3A have averaged around 0.2 MMH/FH during their operational life. The F-14A has averaged between 0.6 and 0.7 MMH/FH once it got beyond its first year of training and operational problems.

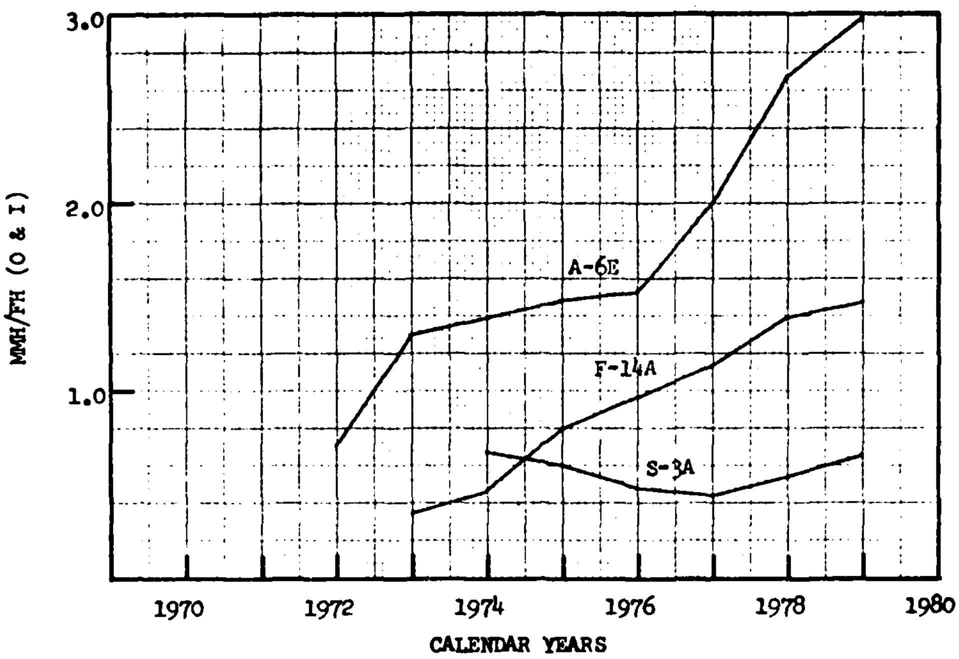

FIGURE 11. SWUC 42 ELECTRICAL SYSTEM MMH/FH TRENDS

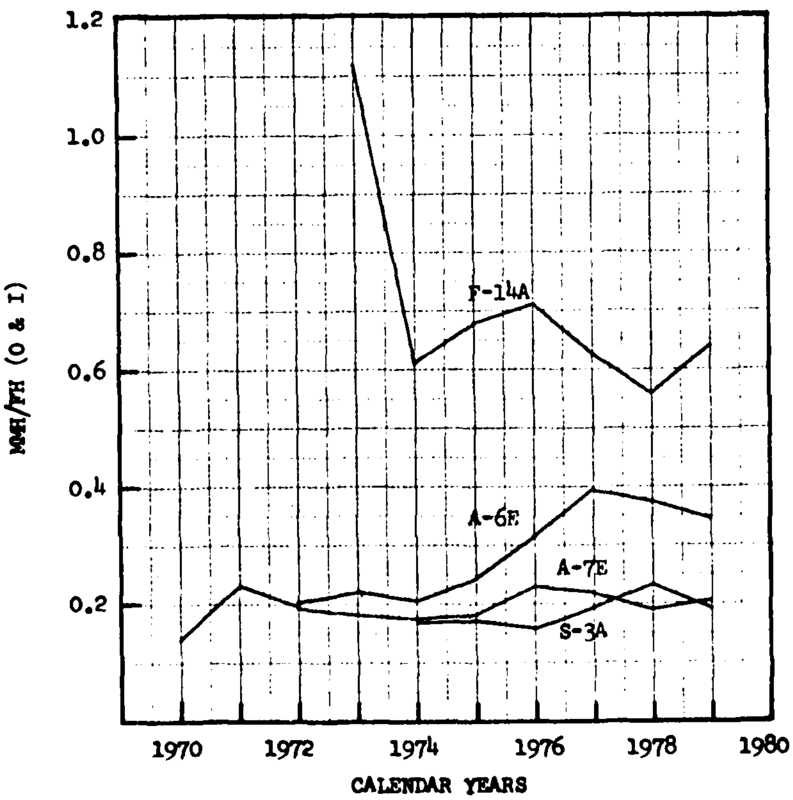

FIGURE 12. SWUC 45 HYDRAULIC SYSTEM MMH/FH TRENDS

Instrument System

Advances in design technology and correction of in-service maintenance problems can sometimes reduce the adverse trend of equipment wear out. Figure 13 shows the S-3A is experiencing a decreasing trend with time in Instrument System (SWUC 51) maintenance. S-3A MMH/FH has been cut in half from its first to its current year of operation. Improvements to the Fuel Quantity Indication Subsystem and Engine Instrumentation Subsystem were two reasons for the decrease. Older generation aircraft such as the A-4M, A-6E and F-4J continue to show equipment wear out problems.

Navigation/Weapon Control

The Navigation/Weapons Control System is comprised of four systems: SWUC 71 (Radio Navigation System), SWUC 72 (Radar Navigation System), SWUC 73 (Bombing Navigation System), and SWUC 74 (Weapons Control System). These systems were grouped together because the Standard WUC's, while an improvement over existing aircraft WUC's, were not definitive enough to allow for comparison between aircraft. The interesting trend about this collective system is that during the past five years it has maintained a fairly constant maintenance rate. The AV-8A is averaging around 2.0 MMH/FH, the A-7E about 3.0, the F-14A between 5.0 and 6.0 and the F-4J between 6.0 and 7.0 as shown in Figure 14.

Total Unscheduled Maintenance

When all the systems are considered collectively, the general trend of increasing MMH/FH over time for all aircraft is readily apparent. Figure 15 shows total unscheduled maintenance trends for the eight T/M/S aircraft.

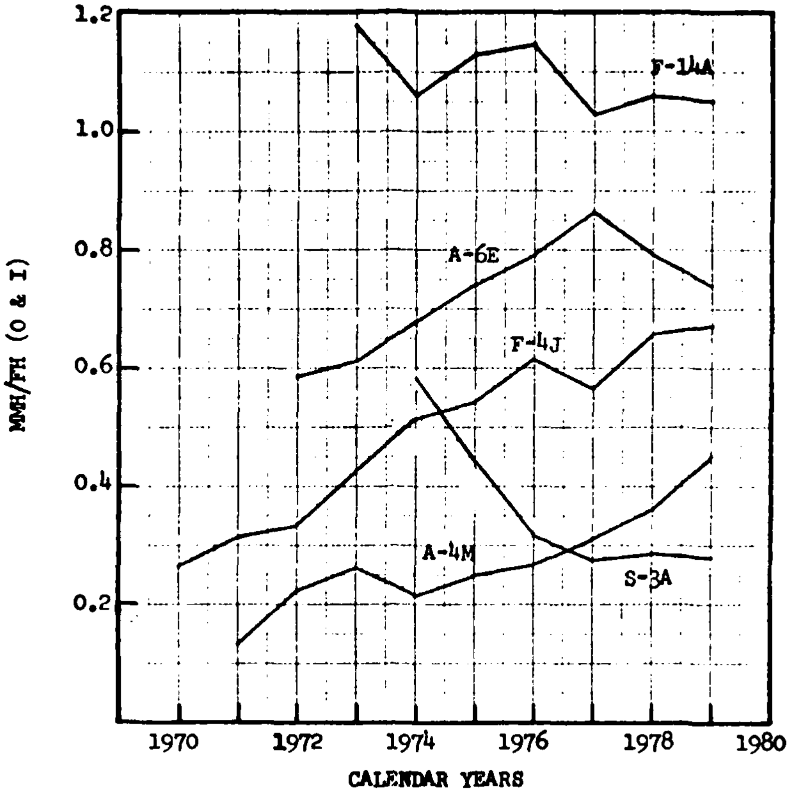

FIGURE 13. SWUC 51 INSTRUMENT SYSTEM MMH/FH TRENDS

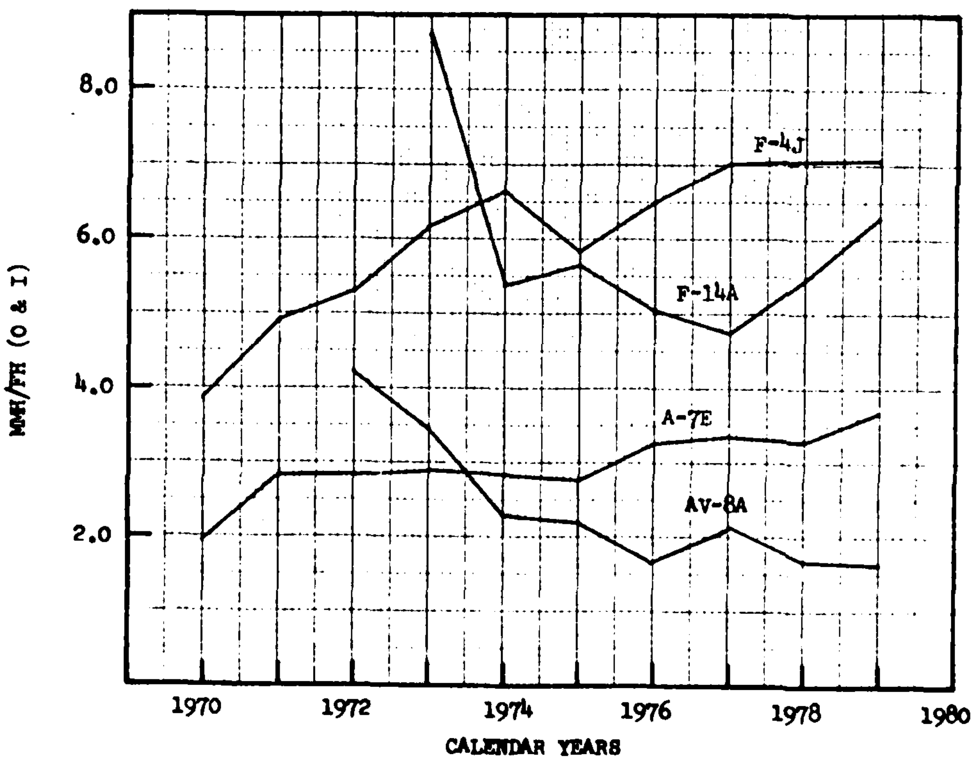

FIGURE 14. SWUC 71/2/3/4 NAVIGATION/WEAPON CONTROL MMH/FH TRENDS

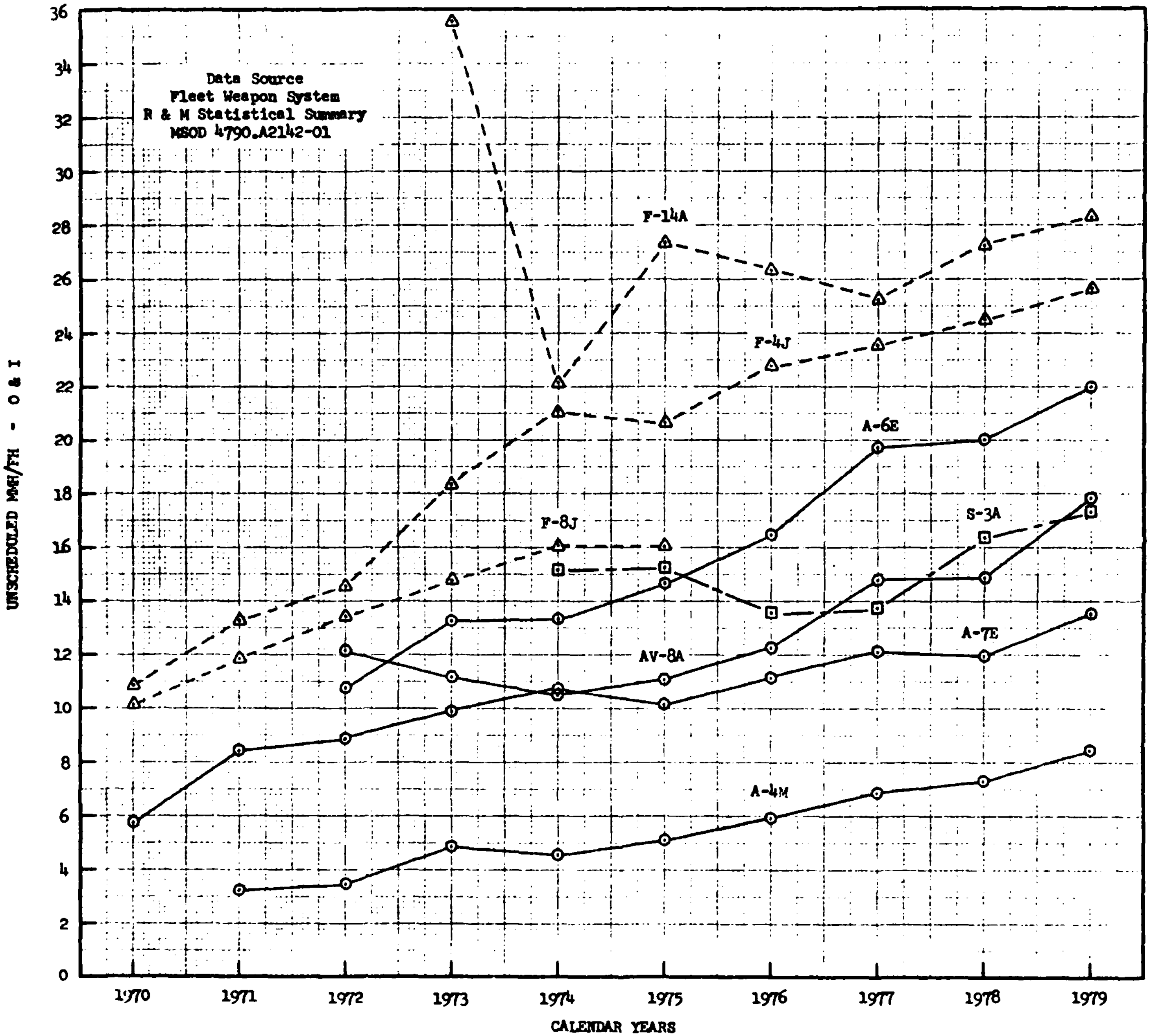

FIGURE 15. UNSCHEDULED MMH/FH TRENDS

Scheduled Maintenance and Support

Maintenance reported against Support Action Codes 01 through 09 comprise the remainder of total 3-M MMH/FH. For this analysis, code 03 (inspections or scheduled maintenance) is defined as SWUC 03 and codes 01, 02, 04-09 are defined as SWUC 01 (support). Annual maintenance trends for these codes tend to follow similar trends as the systems. Figure 16 shows scheduled maintenance trends for the AV-8A, F-4J and F-14A have increased at a higher rate than the other aircraft. The sharp increase between 1978 and 1979 data can be attributed to a cut back in aircraft utilization rather than increased inspection times. Figure 17 shows support MMH/FH varies considerably from year to year with a general increasing trend. MMH/FH reported against this code has been shown to be primarily a function of unscheduled system maintenance. Aircraft exhibiting higher unscheduled maintenance tend to require more support MMH/FH, e.g., ground handling, shop support. Analysis showed that support comprises about one-third of the reported total aircraft MMH/FH.

Total Aircraft Maintenance

The summation of unscheduled maintenance, scheduled maintenance and support results in total aircraft maintenance. Figure 18 shows total aircraft MMH/FH trends for each aircraft by calendar year.

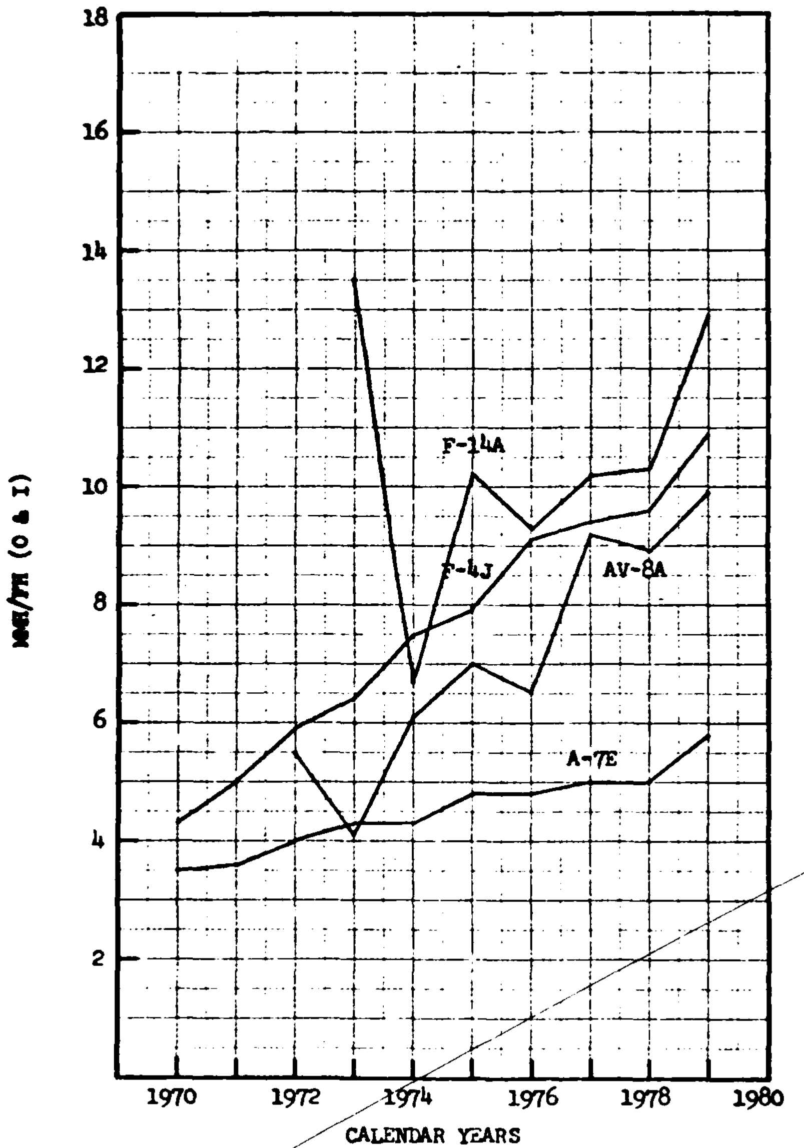

FIGURE 16 SWUC 03 SCHEDULED MMH/FH TRENDS

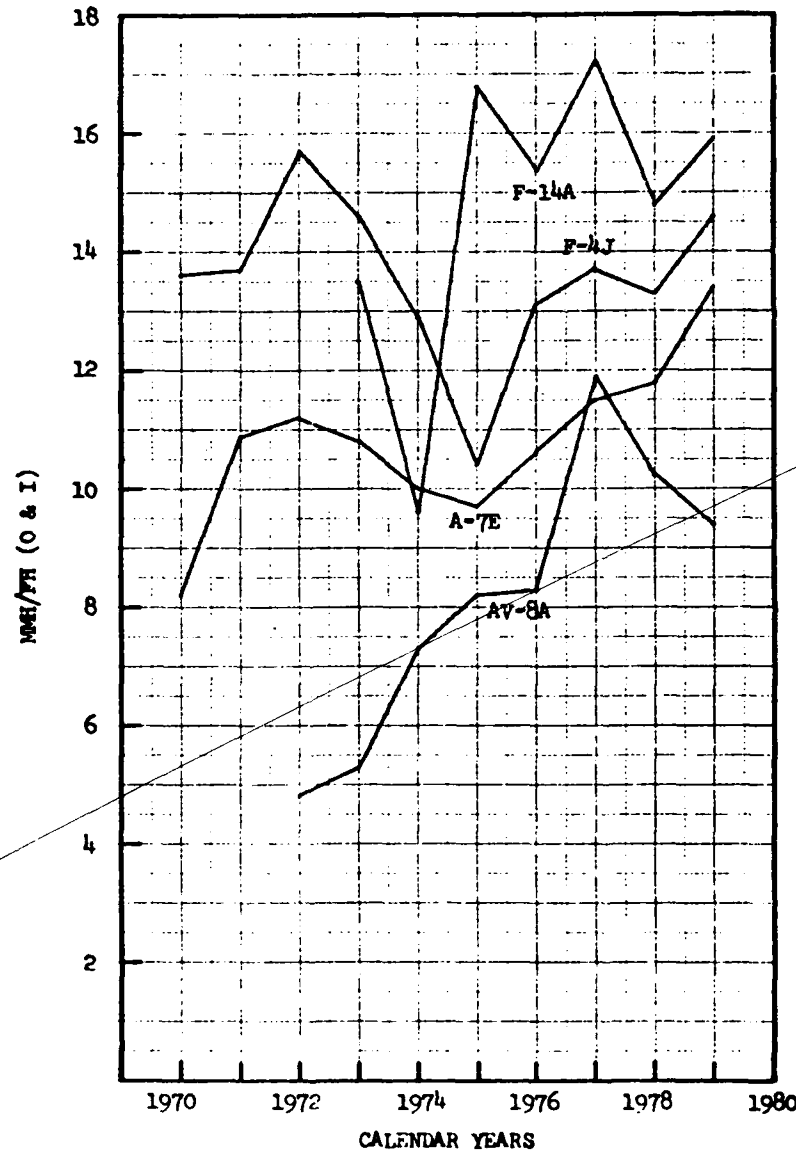

FIGURE 17 SWUC 01 SUPPORT MMH/FH TRENDS

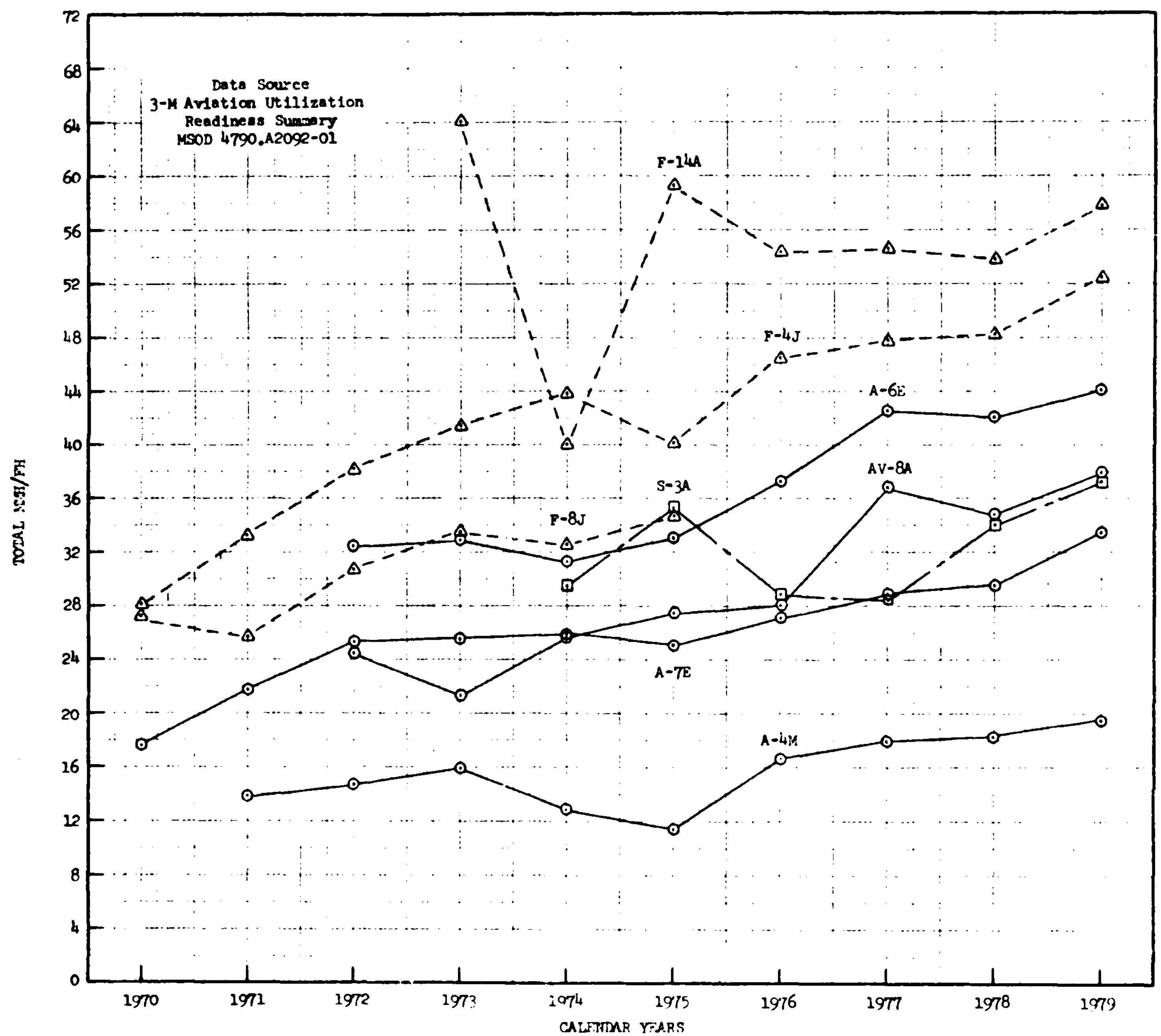

FIGURE 18 TOTAL AIRCRAFT MMH/FH TRENDS

4.0 MODEL UPDATE

This phase of the study addresses two procedures for updating the Maintainability Index Model: (1) an interim update using Maintenance Inflation Factors and (2) a complete update using a new data base. Emphasis was placed on the interim model update because of the variability of annual 3-M data.

4.1 BASIC MODEL

The basic premise for the Maintainability Index Model was that MMH/FH and MA/FH predictions for a given two-digit SWUC could be represented by the linear statistical equation:

$$Y = b_o + \sum_{j=1}^{P} b_j x_j \qquad \text{Eq. (1)}$$

where

Y = dependent variable to be calculated; either MMH/FH or MA/FH

b_o, b_1 ..... b_p are coefficients derived through regression analysis and

x_1, x_2 ..... x_p are selected aircraft design and performance parameters.

The two dependent variables calculated resulted in a set of estimating relationships called Maintenance Index (MI) equations and Frequency Index (FI) equations as shown in Tables 7 and 8. The equations are used to determine MMH/FH and MA/FH at the Organizational level, respectively. Allowances for Intermediate level maintenance were made by incorporating Maintenance Index

TABLE 7. BASELINE O-LEVEL MMH/FH ESTIMATING RELATIONSHIPS

STD WUC	SYSTEM	MAINTENANCE INDEX EQUATIONS
11,12	AIRFRAME/FUSELAGE	MI = −0.2180 + 0.5692 ln (WTMT) + 0.8394 ln (VMAX)
13	LANDING GEAR	MI = 0.1738 + 0.0241 (WTLAND)
14	FLIGHT CONTROLS	MI = −0.3963 + 0.0274 (WTMT) + 0.8036 (VMAX) + 0.569 (KWING)
23	ENGINE	MI = −0.3960 + 0.0467 (THRUST) + 0.3414 (ENGQTY)
24	AUXILIARY POWER PLANT	MI = 0.192 (KAPU)
29	POWER PLANT INSTL	MI = −0.0943 + 0.0059 (THRUST) + 0.1174 (ENGQTY)
41	AIR-CONDITIONING	MI = −0.0717 + 0.0103 (WTMT) + 0.0364 (WTAVIN) + 0.166 (KBLC)
42	ELECTRICAL	MI = −0.1419 + 0.0259 (WTMT) −0.0485 (GENKVA)
44	LIGHTING	MI = −0.2305 + 0.1652 (WAREA) +0.6472 (FUSLEN)
45	HYDRAULICS	MI = −0.1260 + 0.0066 (WTMT) + 0.3671 (VMAX)
46	FUEL	MI = −0.2947 + 0.1148 (FUEL) + 0.6060 (VMAX)
47	OXYGEN	MI = 0.034
49	MISC UTILITIES	MI = −0.0275 + 0.0028 (WTMT)
51	INSTRUMENTS	MI = 0.0465 + 0.2906 (WTAVUN)
56	FLIGHT REFERENCE	MI = −0.0890 + 0.2182 (WTAVIN)
57	INTEG GUID/FLT CONTROL	MI = −0.3225 + 0.1783 ln (WTMT)
60	COMMUNICATIONS	MI = 0.0428 + 0.0104 (WTMT) + 0.0460 (WTAVIN)
71, 72 73, 74	NAV/WEAPON CONTROL	MI = 1.3541 + 0.8715 ln (WTAVUN)
75	WEAPON DELIVERY	MI = −0.1563 + 0.0040 (WTMT) + 0.0367 (PYLQTY) + 0.082 (KGUN)
76	ECM	MI = −0.0645 + 0.0104 (WTMT)
90	MISC EQUIPMENTS	MI = 0.0272 −0.0012 (WTMXTO) + 0.0491 (CREW) + 0.014 (KCHUTE)
01	OPERATIONAL SUPPORT	MI = −7.9012 + 5.3533 ln (WTMT) − 1.9394 ln (SL)
012	SERVICING	MI = 1.3441 + 0.0046 (WTMT) − 0.2573 (SL)
016	TROUBLESHOOT LAUNCH AIRCRAFT	MI = −3.3681 + 1.3259 ln (WTCOM)
02	CLEANING	MI = 0.188
03C	TURNAROUND/PREFLIGHT	MI = −0.0282 + 0.0346 (WTCOM)
03D	DAILY/SPECIAL	MI = 2.3571 + 0.0948 (WTMT) − 1.1568 (SL)
03G	PHASE	MI = 0.1455 + 0.0186 (WTMT) + 0.2962 (T/W)
03S	CONDITIONAL	MI = −0.4956 + 0.0229 (WTMT) + 0.0224 (DEN)
03Z	OTHER	MI = −0.4068 + 0.3538 (FUSWET) + 0.5392 (T/W)
04	CORROSION PREVENTION	MI = −2.6456 + 2.6493 (FUSWET) + 1.5454 (T/W)
05	SHOP SUPPORT	MI = −0.3510 + 0.3613 ln (WTMT) + 0.4916 ln (T/W)

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SOURCE: Aircraft Maintenance Experience Design (AMED) Handbook (Reference 1)

TABLE 8. BASELINE O-LEVEL MA/FH ESTIMATING RELATIONSHIPS

STD WUC	SYSTEM	FREQUENCY INDEX EQUATIONS
11,12	AIRFRAME FUSELAGE	FI = -0.2931 + 0.1800 ln (WTMT) + 0.0525 ln (VMAX)
13	LANDING GEAR	FI = 0.1019 + 0.1850 (KE)
14	FLIGHT CONTROLS	FI = 0.0112 + 0.1183 (VMAX) + 0.022 (KWING)
23	ENGINE	FI = -0.0194 + 0.0023 (THRUST) + 0.0340 (ENGQTY)
24	AUXILIARY POWER PLANT	FI = 0.037 (KAPU)
29	POWER PLANT INSTL	FI = 0.0069 + 0.0023 (THRUST) + 0.0028 (ENGQTY)
41	AIR CONDITIONING	FI = 0.0019 + 0.0013 (WTMT) + 0.0072 (WTAVIN) + 0.016 (KBLC)
42	ELECTRICAL	FI = 0.0100 + 0.0027 (WTMT) + 0.0092 (GENKVA)
44	LIGHTING	FI = 0.1458 -0.0333 (WAREA) + 0.4444 (FUSLEN)
45	HYDRAULICS	FI = 0.0191 + 0.0361 (VMAX)
46	FUEL	FI = 0.0056 + 0.0465 (VMAX)
47	OXYGEN	FI = 0.019
49	MISC UTILITIES	FI = -0.0036 + 0.0004 (WTMT)
51	INSTRUMENTS	FI = 0.0360 + 0.0467 (WTAVUN)
56	FLIGHT REFERENCE	FI = -0.0106 + 0.0483 (WTAVIN)
57	INTEG GUID/FLT CONTROL	FI = 0.0376 + 0.0201 ln (WTAVUN)
60	COMMUNICATIONS	FI = 0.0194 + 0.0037 (WTMT) + 0.0190 (WTAVIN)
71, 72 73,74	NAV/WEAPON CONTROL	FI = 0.3616 + 0.2379 LN (WTAVUN)
75	WEAPON DELIVERY	FI = -0.0087 + 0.0006 (WTMT) + 0.0034 (PYLQTY) + 0.017 (KGUN)
76	ECM	FI = -0.0049 + 0.0016 (WTMT)
90	MISC EQUIPMENTS	FI = -0.0057 -0.0003 (WTMXTO) + 0.0267 (CREW) + 0.007 (KCHUTE)
01	OPERATIONAL SUPPORT	FI = 1.8159 + 1.5686 (FUSWET) + 0.4695 (SL)
012	SERVICING	FI = 1.2895 - 0.4381 ln (SL) + 0.2970 ln (VMAX)
016	TROUBLESHOOT LAUNCH AIRCRAFT	FI = -0.0378 + 0.1339 (WTAVIN) + 0.4677 (T/W)
02	CLEANING	FI = 0.097
03C	TURNAROUND/PREFLIGHT	FI = 0.5305 + 0.0208 (WTMT) - 0.1358 (SL)
03D	DAILY/SPECIAL	FI = -0.5132 + 0.7166 (FUSWET) + 0.7052 (T/W)
03G	PHASE	FI = 0.025
03S	CONDITIONAL	FI = -0.3111 + 0.0561 LN (WTMT) + 0.0701 LN (DEN)
03Z	OTHER	FI = -0.0760 + 0.0245 (T/W) + 0.0074 (DEN)
04	CORROSION PREVENTION	FI = 0.3948 + 0.3130 ln (FUSWET)
05	SHOP SUPPORT	FI = -0.0316 + 0.0131 (WTMT) + 0.1675 (T/W)

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SOURCE: AMED Handbook (Reference 1)

I-Level Ratios (MIIR) and Frequency Index I-Level Ratios (FIIR) into the model as shown in Table 9.

TABLE 9. BASELINE I-LEVEL RATIOS

SWUC	MIIR	FIIR	SWUC	MIIR	FIIR	SWUC	MIIR	FIIR
11/12	.04	.07	47	.98	.37	01	.01	.03
13	.43	.44	49	.19	.35	02	.08	.12
14	.10	.13	51	.16	.29	03C	.00	.00
23	.36	.33	56	.83	.40	03D	.00	.00
24	.22	.23	57	.54	.33	03G	.07	.05
29	.11	.21	60	.88	.36	03S	.01	.01
41	.11	.21	71/2/3/4	.94	.43	03Z	.16	.09
42	.15	.22	75	.59	.46	04	.04	.09
44	.25	.09	76	.83	.35	05	.77	.65
45	.13	.20	90	.18	.16			
46	.04	.13						

SOURCE: AMED Handbook (Reference 1)

4.2 INTERIM UPDATE USING MAINTENANCE INFLATION FACTORS

The variability and instability of annual 3-M data has affected maintainability prediction capability. During the three years since model development, life cycle data has increased while MIM data base data and MIM calculated values have remained constant. In order to bring the model back in line to reflect this latest change, a procedure was established that would bias each predicted MMH/FH and MA/FH value by a constant called a Maintenance Inflation Factor (MIF).

Maintenance inflation is defined as the change in historical data relative to model output. As regards life cycle data, a MIF can be determined by measuring the change in life cycle data relative to MIM calculated values for each aircraft and summed according to the following equation:

$$MIFL = \frac{\sum \left(\frac{LCD_i}{CAL_i} - 1 \right) 100}{n} \qquad \text{Eq. (2)}$$

where

MIFL = Maintenance Inflation Factor for Life Cycle Data relative to model output

LCD_i = Life Cycle Data at O and I-level for the i^{th} aircraft for a given SWUC

CAL_i = Model Calculated Data at O and I-level for the i^{th} aircraft for a given SWUC

n = Number of aircraft

For each system, two MIF's can be determined: one to bias MMH/FH data and the other to bias MA/FH data.

Combining equations (1) and (2) and solving for the appropriate maintainability parameter results in the following:

$$\frac{MMH_{O,I}}{FH} = \left(MI_i\right)\left(1 + MIIR_i\right)\left(1 + \frac{MIMIFL_i}{100}\right) \qquad \text{Eq. (3)}$$

$$\frac{MA_{O,I}}{FH} = \left(FI_i\right)\left(1 + FIIR_i\right)\left(1 + \frac{FIMIFL_i}{100}\right) \qquad \text{Eq. (4)}$$

where

MI_i = Maintenance Index (MMH/FH at O-level) for the i^{th} SWUC

FI_i = Frequency Index (MA/FH at O-level) for the i^{th} SWUC

$MIIR_i$ = Maintenance Index I-Level Ratio; system constant for I-level MMH/FH

$FIIR_i$ = Frequency Index I-Level Ratio; system constant for I-level MA/FH

$MIMIFL_i$ = Maintenance Inflation Factor for Life Cycle MMH/FH data for the i^{th} SWUC

$FIMIFL_i$ = Maintenance Inflation Factor for Life Cycle MA/FH data for the i^{th} SWUC

Thus, model update can be accomplished by solving each system index equation, allowing for I-level maintenance and adjusting the existing model output for maintenance inflation. MIIR and FIIR values were not changed because analysis on selected aircraft (A-7E and S-3A) showed that the percentage of O and I-level maintenance remained fairly constant with time.

4.2.1 Airframe/Fuselage System Update

To show how the MIM can be updated, the Airframe/Fuselage System was chosen as an example. Using data previously presented in Table 6, MIM calculated MMH/FH was plotted as a function of life cycle MMH/FH. Figure 19 shows that the model under predicts Airframe/Fuselage System maintenance (dash line). Solving equation (2), results in MIFL = 31.2%. That is, by increasing the MIM calculated MMH/FH for each aircraft by 31.2%, the model is brought back in line with historical data (solid line).

A similar analysis was done for MA/FH with one additional intermediate step. The MIM was originally developed using Vought computer routines which classify maintenance actions differently than NAMSO computer routines. Vought data reduction shows 20 to 30 percent less maintenance actions than NAMSO for the same data.

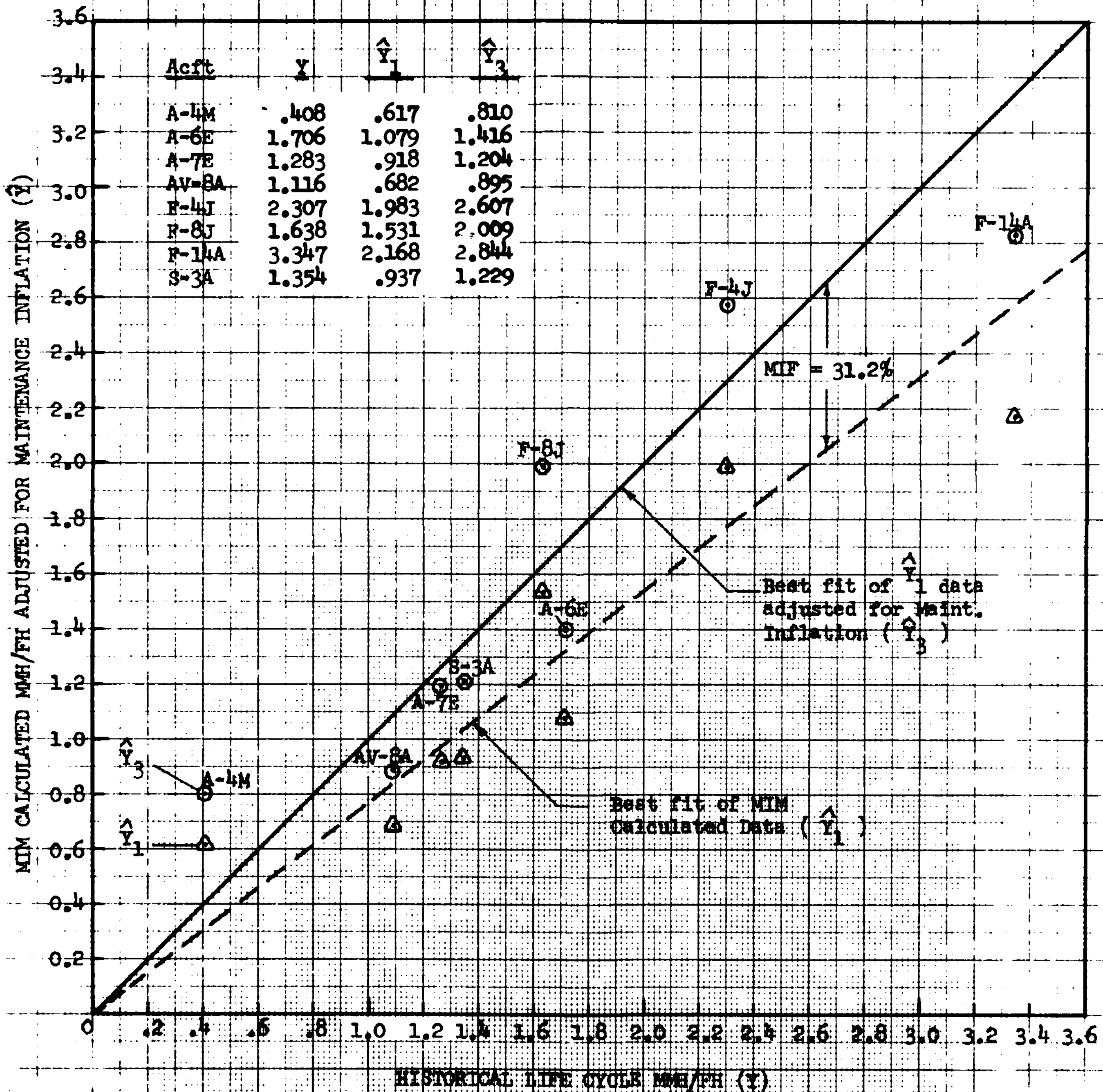

FIGURE 19: AIRFRAME/FUSELAGE SYSTEM MMH/FH ADJUSTED FOR MAINTENANCE INFLATION

NAMSO defines a maintenance action as each change in Job Control Number (JCN), less suffix, for a given 5 digit WUC with Card Codes 11, 21 and 31. Thus, O-level actions (CC 11 and 21) reported in reference (2) are combined with I-level actions (CC 31). Vought sorts the data by JCN so that all records involving a single maintenance action are collected together. O and I-level maintenance actions are reported separately. NAMSO counts malfunctions with Action Taken Codes P (Removal), Q (Installed), T (Removed for Cannibalization) and U (Installed for Cannibalization) as separate actions. Vought establishes a dominant record by matching JCN's and combines P and Q malfunctions as one action. Similarily for T and U. An item removed for cannibalization (T) from one aircraft and later re-installed on that aircraft (code U) is counted as one action.

To account for these variations in data reduction, NAMSO data was compared to MIM data base data for like time periods and a conversion factor was established for each system. MIM calculated values were then adjusted accordingly. Figure 20 shows that a Maintenance Inflation Factor of 12.0% is required to update the model to life cycle data.

4.2.2 <u>Model Update To Life Cycle Data</u>

A comparison between MIM data base MMH/FH and life cycle MMH/FH for all aircraft was made to identify those systems that have changed the most since model development. System ranking is shown in Table 10.

SWUC 56 (Flight Reference System) showed the greatest gain primarily due to the addition of new equipment to the A-4M and the high maintenance rate for the A-6E and AV-8A. Seven systems showed Maintenance Inflation Rates of 25% or more: four were mechanical systems and three were avionic systems. SWUC 03

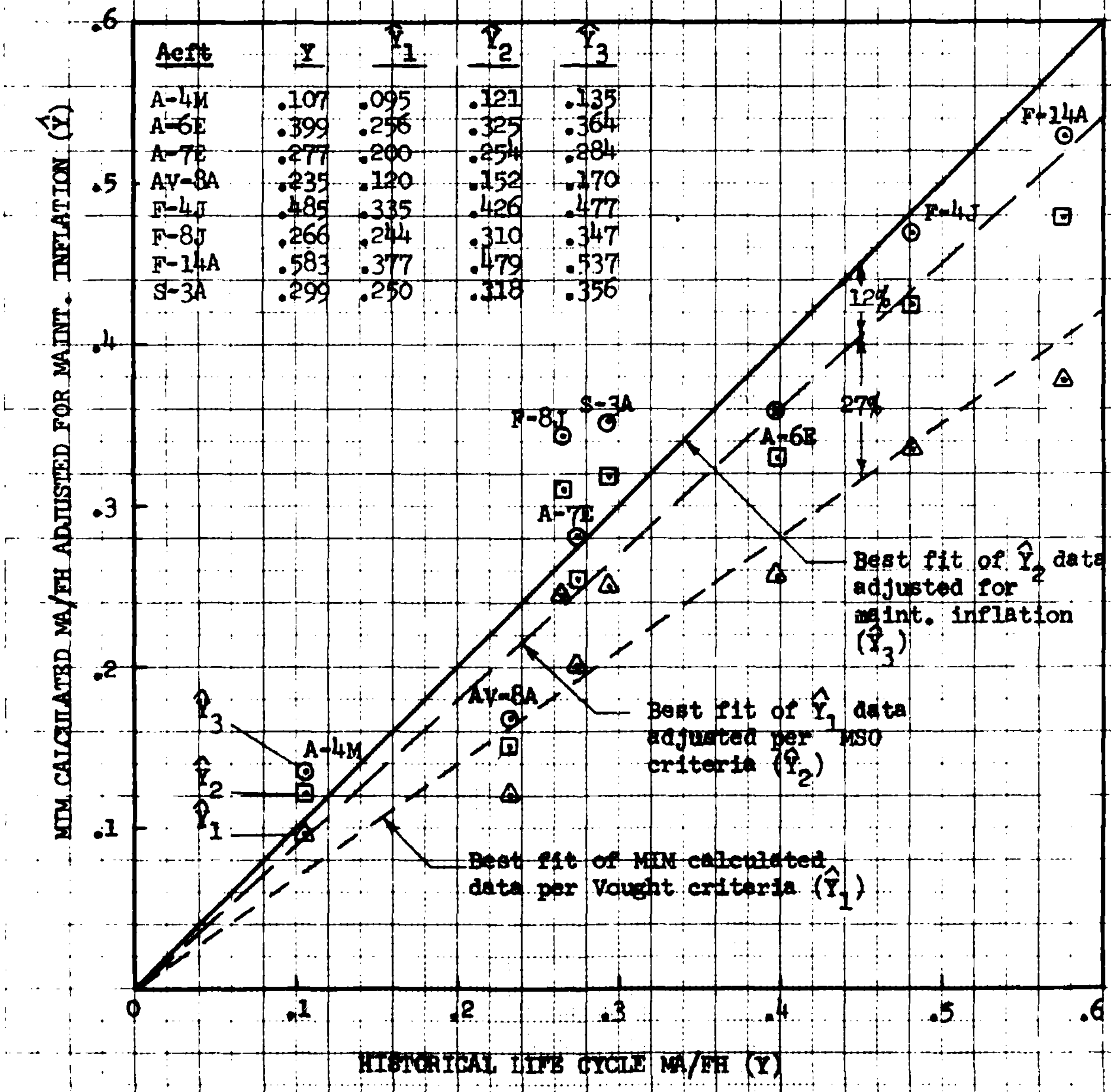

FIGURE 20: AIRFRAME/FUSELAGE SYSTEM MA/FH ADJUSTED FOR MAINTENANCE INFLATION

(Scheduled Maintenance) increased 23.7% while SWUC 01 (Support) remained unchanged.

TABLE 10. PERCENT CHANGE IN LIFE CYCLE MMH/FH RELATIVE TO MIM DATA BASE MMH/FH

SWUC	%	SWUC	%	SWUC	%
56	47.0	60	22.7	90	4.6
29	30.8	75	20.7	45	4.2
11/12	28.1	42	20.4	51	2.5
76	27.5	71/2/3/4	18.0	01	0.8
46	26.7	44	14.5	13	0.7
49	26.7	41	13.5	24	0.1
57	26.3	14	10.6	47	-4.2
03	23.7	23	5.4		

In order to determine the net impact on the model, life cycle data was compared with MIM calculated data. Only those aircraft that were used in each index equation were analyzed for maintenance inflation. This prevented aircraft with abnormal system maintenance characteristics from distorting the model output. Maintenance Inflation Factors were then calculated for each system. Table 11 lists these factors for both MMH/FH (MIF1) and MA/FH (MIF2).

TABLE 11. MAINTENANCE INFLATION FACTORS FOR UPDATING MODEL TO LIFE CYCLE DATA

SWUC	MIF1	MIF2	SWUC	MIF1	MIF2	SWUC	MIF1	MIF2
11/12	31.2	12.0	44	10.0	12.3	60	13.1	9.6
13	1.2	3.5	45	-10.3	0.1	71/2/3/4	28.5	6.5
14	18.1	-3.5	46	26.9	-0.1	75	-6.0	19.3
23	10.8	-1.3	47	-3.9	-9.6	76	39.5	19.7
24	10.9	11.6	49	4.8	62.0	90	1.0	-6.8
29	31.2	18.1	51	6.2	5.2	03	21.2	N/A
41	0.0	5.5	56	14.3	12.6	01	1.0	N/A
42	6.8	1.5	57	24.1	6.5			

(1) MIF1 = Percent change in life cycle MMH/FH relative to model calculated MMH/FH

(2) MIF2 = Percent change in life cycle MA/FH relative to model calculated MA/FH

N/A = Not Applicable

4.2.3 Model Update To Current Year Data

A much greater increase in maintenance was noted when MIM calculated data was compared to current year (1979) data. If the model is to be updated to current year data, then the Maintenance Inflation Factors presented in Table 12 should be used. These factors were developed using the same procedures that were used to develop MIF1 and MIF2 only current year data was used.

TABLE 12. MAINTENANCE INFLATION FACTORS FOR UPDATING MODEL TO CURRENT YEAR DATA

SWUC	MIF3	MIF4	SWUC	MIF3	MIF4	SWUC	MIF3	MIF4
11/12	69.3	44.3	44	49.4	26.2	60	55.9	14.5
13	12.4	3.0	45	-7.7	-12.1	71/2/3/4	38.6	-5.9
14	41.4	11.8	46	51.5	2.2	75	35.0	61.3
23	46.8	18.4	47	14.8	-27.4	76	35.1	32.1
24	29.0	21.0	49	14.4	76.7	90	31.4	3.0
29	74.2	45.6	51	26.9	1.6	03	46.2	N/A
41	19.8	10.5	56	19.9	47.1	01	7.5	N/A
42	47.9	17.3	57	68.4	7.7			

(1) MIF3 = Percent change in current year MMH/FH relative to model calculated MMH/FH
(2) MIF4 = Percent change in current year MA/FH relative to model calculated MA/FH
N/A = Not Applicable

4.2.4 Model Validation

Model validation was accomplished by adjusting model outputs for maintenance inflation and comparing calculated data with actual data. Equations (3) and (4) were solved for each SWUC and for each aircraft. Results were summed and plotted against actual data as depicted in Figures 21, 22, 23 and 24. Validation was done for both life cycle and current year MMH/FH and MA/FH.

Results indicated that the model can be updated using MIF's without significantly degrading model outputs. Only the AV-8A and S-3A suffered slight

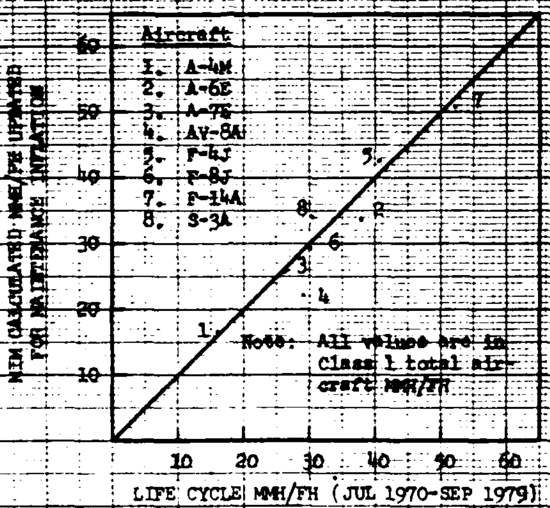

FIGURE 21. MODEL UPDATE TO LIFE CYCLE MMH/FH

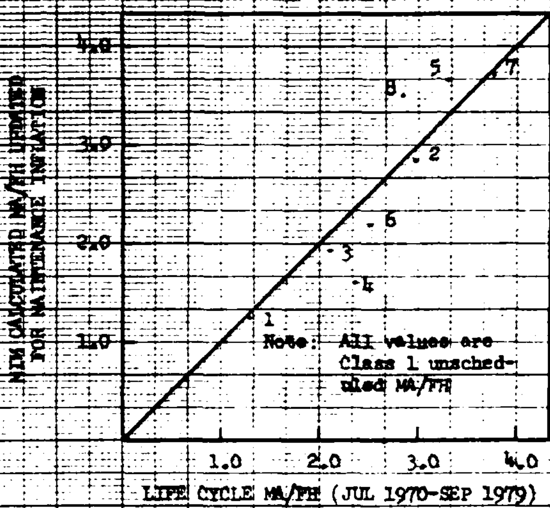

FIGURE 22. MODEL UPDATE TO LIFE CYCLE MA/FH

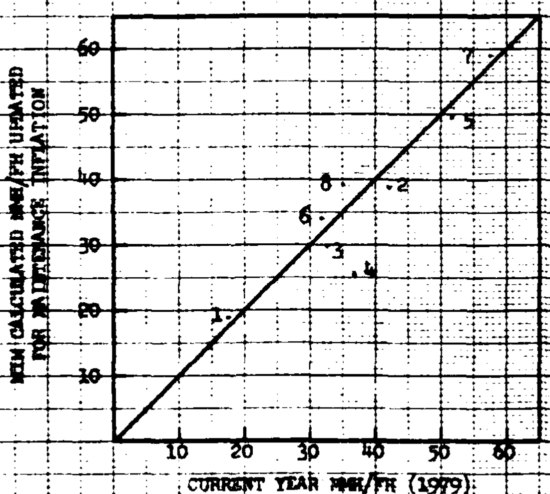

FIGURE 23. MODEL UPDATE TO CURRENT YEAR MMH/FH

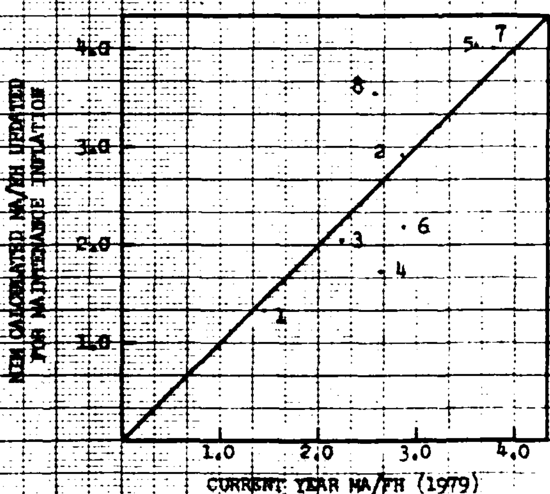

FIGURE 24. MODEL UPDATE TO CURRENT YEAR MA/FH

degradation with the model under predicting AV-8A and over predicting S-3A maintenance requirements.

4.3 COMPLETE UPDATE USING A NEW DATA BASE

A complete update of the Maintainability Index Model is recommended every five years because of the variability of annual 3-M data and the effort required to reduce the data to a usable format. Table 13 outlines three data source options along with data element availability. Options are discussed below in order of increasing program cost.

Option #1 - NAMSO Data

The lowest cost approach for complete model update is the use of NAMSO data adjusted for O-level maintenance and Class 3 maintenance. NAMSO reports do not breakdown data into O and I-levels and they do not provide sufficient detail to establish Class 3 maintenance. As a result, parameters such as MMH_O/FH and MA_O/FH for the eight T/M/S aircraft have to be estimated using system constants developed in the AMED Handbook. The use of NAMSO data requires that the following assumptions be made: I-level ratios (MIIR, FIIR) and defect ratios (MIDR, FIDR) have not significantly changed from the 1975/1976 time period.

A comprehensive data base already has been established for this option, excerpts of which are shown in Appendices A and B. Note, this is the only option available for calculating life cycle estimating relationships.

Option #2 - NALCOMIS Data

The Naval Aviation Logistics Command Management Information System (NALCOMIS) data reports (reference 4) generated by NADC present system

maintenance and support data for T/M/S aircraft by fiscal year. The advantage of using this report over Option #1 is that O and I-level data is reported separately allowing for direct calculation of MMH_O/FH and MA_O/FH estimating relationships. The drawbacks are (1) Class 3 maintenance is not available (MIDR and FIDR values from the AMED Handbook would have to be used), (2) data is only reported at the two digit WUC level preventing conversion to a Standard WUC and (3) data coded under Support Action Codes 01, 02, 04-09 is not reported.

Option #3 - 3-M Data Tapes

This option fulfills all data element requirements except life cycle data. The use of 3-M data tapes was the approach used to develop the existing model. Because of the increasing trend in aircraft maintenance, selection of the largest data base possible is recommended for model update. The use of a one year data base such as the latest current year data will restrict the model to a set of data which is not representative of a mature aircraft. Program costs for Option #3 are a function of the size of the data base, e.g., number of maintenance records to be processed.

TABLE 13. DATA SOURCE OPTIONS FOR COMPLETE MODEL UPDATE

DATA ELEMENT	UPDATE OPTIONS(1) #1	#2	#3
Report Title	NAMSO	NALCOMIS	3-M Tapes
Time Period			
Life Cycle	Y	N	N
Current Year	Y	Y(2)	Y
Class of Maintenance			
Class 1	Y	Y	Y
Class 3	N	N	Y
Type Maintenance			
Unscheduled	Y	Y	Y
Scheduled	Y	Y	Y
Support	Y	N	Y
Parameters			
MMH_O/FH	N	Y	Y
MA_O/FH	N	Y	Y
EMT_O/MA_O	N	N	Y
MEN_O/MA_O	N	N	Y
$MMH_{O,I}/FH$	Y	Y	Y
$MA_{O,I}/FH$	Y	Y	Y
System Constants			
MIIR	N(3)	Y	Y
FIIR	N(3)	Y	Y
MEN	N(3)	N(3)	Y
MIDR	N(3)	N(3)	Y
FIDR	N(3)	N(3)	Y
Standard WUC	Y	N(4)	Y

(1) Data element available (Y = Yes, N = No)
(2) Fiscal year only
(3) Use system constants developed in the AMED Handbook
(4) Insufficient data available to convert to a Standard WUC

4.4 AUTOMATIC DATA PROCESSING

Can Automatic Data Processing (ADP) be used to update the MIM annually or on an as need be basis? Specifically, can a program be written that will (1) take raw 3-M data and a list of aircraft design parameters and through a regression analysis program develop estimating relationships at the two-digit WUC level, (2) print out the resulting index equations and corresponding data tables and (3) graphically plot the index equations?

Ideally, it would be nice to re-calculate 64 MI and FI equations and replace 181 pages of Section 5 of the AMED Handbook with a computer printout. Realistically, it is not possible without some human intervention. Many subjective inputs are required in selecting applicable design parameters and determining abnormal maintenance behavior of some aircraft systems.

For example, a regression analysis program may select avionics weight and fuel capacity for the Landing Gear System MI equation which may be statistically valid but not design applicable. Because weight landing in a clean configuration was initially selected does not necessarily mean it would be selected again with a new data base. An analyst must insure the parameters are both statistically valid and design applicable.

Also, the model was designed to be independent of system maintenance peculiarities unique to a given aircraft. Ground rules established for a system regression analysis permitted excluding those aircraft which exhibited [illegible] maintenance. If a satisfactory regression analysis could not be [illegible] using all eight aircraft, those aircraft in the minority were deleted [illegible] system analysis. To include them would have distorted the trend for a [illegible] the aircraft, lowered system regression correlation and decreased

the effectiveness of the model. The relationship between design and maintenance would be degraded. An analyst must make this decision.

ADP can be used to some extent to update the model. System regression analysis summary and maintenance data summary tables in the handbook can be updated with computer printouts. Graphical plotting can be used to draw the index equation graphs. However, the calculations of the index equations should be left as a separate routine requiring the subjective input of an analyst.

5.0 MODEL UTILIZATION

The Maintainability Index Model was initially developed for manual operation by solving index equations, graphs and worksheets presented in the AMED Handbook. Later this year, a MIM computer program will be on line to do all calculations including interim model update. Information presented in this section is intended to show the user examples of an interim model update.

5.1 AIRCRAFT MAINTENANCE EXPERIENCE DESIGN (AMED) HANDBOOK

The Aircraft Maintenance Experience Design Handbook presents guideline procedures for evaluating contractor Maintainability (M) predictions during source selection or for establishing realistic M requirements. The handbook contains a Maintainability Index Model which is used to functionally relate historical maintenance data at the two-digit WUC level to aircraft design characteristics. Contractor M predictions also are included in the model.

The model calculates MMH/FH, MA/FH and Mean Time to Repair (MTTR) at O and I-levels by SWUC for both a baseline and a predicted design. Baseline maintenance identifies a state-of-the-art design according to the aircraft's characteristics. Predicted maintenance identifies a next generation design with greater emphasis on Reliability and Maintainability (R&M) and advances in design technology. The difference between the two is the measure of technology improvement over today's aircraft. For each case, two values are determined: a Fleet reported value (Class 1) which identifies operational M as measured in 3-M data reports and a design related value (Class 3) which identifies inherent M as demonstrated under controlled conditions.

An example of the method used for adjusting the MIM to incorporate the MIF's is given in the following paragraphs.

5.1.1 Airframe/Fuselage System Prediction

This example investigates the change in aircraft maintenance requirements as the model is updated from a mid-1970's data base to a life cycle data base and current year data base. As with any analysis, a change in the point of reference will affect the calculated answer. The F/A-18 aircraft will be evaluated for SWUC 11/12 (Airframe/Fuselage System) maintenance requirements. Applicable input parameters are listed below:

WTMT = 20.583 Weight Empty x 10^3 lbs

VMAX = 1.085 Max. Speed at Altitude x10^3 knots

BMIIR = 0.04 Baseline Maintenance Index I-Level Ratio

MIF1 = 31.2 Maintenance Inflation Factor used to update model to life cycle data, %

MIF2 = 69.3 Maintenance Inflation Factor used to update model to current year data, %

Solving the baseline Maintenance Index (MI) equation for SWUC 11/12 yields,

$$MI_O = -0.2181 + 0.5692 \ln (WTMT) + 0.8394 \ln (VMAX)$$

$$= -0.2181 + 0.5692 \ln (20.583) + 0.8394 \ln (1.085)$$

$$= 1.572 \ MMH_O/FH$$

Allowing for I-level maintenance results in,

$$MI_{O,I} = MI_O \quad (1 + BMIIR)$$

$$= 1.572\ (1 + 0.04)$$

$$= 1.635\ MMH_{O,I}/FH$$

Updating the model to the latest life cycle data base yields,

$$YMI_{O,I} = MI_{O,I} \left(1 + \frac{MIF1}{100}\right)$$

$$= 1.635 \left(1 + \frac{31.2}{100}\right)$$

$$= 2.145 \quad MMH_{O,I}/FH$$

Updating the model to the latest current year (1979) data base yields,

$$ZMI_{O,I} = MI_{O,I} \left(1 + \frac{MIF2}{100}\right)$$

$$= 1.635 \left(1 + \frac{69.3}{100}\right)$$

$$= 2.768 \quad MMH_{O,I}/FH$$

Depending on the data base used, F/A-18 baseline maintenance requirements for SWUC 11/12 will vary from 1.635 to 2.768 $MMH_{O,I}$/FH. Since the contractor's predictions remain fixed, a greater divergence between baseline and predicted maintenance occurs. Assuming the aircraft meets its predictions, a higher Technology Improvement Factor (TIF) will be measured. Table 14 shows this comparison where an initially measured TIF of 41% increases to 55% when a life cycle data base is used, and to 65% when a current year data base is used. In actuality, these additional TIF increases are directly related to the MIF. F/A-18 design characteristics and the initial TIF have not changed, only the data base or point of reference has changed.

TABLE 14. F/A-18 MMH/FH PREDICTION UPDATE

DATE BASE	TIME FRAME	MODEL BASELINE	PREDICTED (1)	TIF %
Existing MIM	Mid 1970's	1.635	.970	41
LCD	1970 Decade	2.145	.970	55
CYD(2)	1979	2.768	.970	65

(1) Contractor's initial Class 3 M prediction (Reference 5) adjusted to Class 1 prediction per AMED Handbook procedures.
(2) Current year data.

5.2 MIM COMPUTER PROGRAM

Vought currently has an on-going task to develop a computer program and user's guide for the Maintainability Index Model. The program will be responsive to aircraft design constraints, contractor M predictions and technology level. Model output will measure the M requirements for a given aircraft at the system and weapons system level in both a controlled and operational environment. Provisions for model update using MIF's will be provided. The

model will be structured to allow for a later addition of trainer aircraft and helicopters.

6.0 CONCLUSIONS AND RECOMMENDATIONS

Vought recommends that the Maintainability Index Model be updated annually through the use of Maintenance Inflation Factors and that the complete MIM data base be updated every five years.

In the three years since MIM development, existing inventory aircraft maintenance expenditure has increased to the point where maintenance increases have seriously affected the model output. Estimating relationships for MMH/FH show predicted values are about 40% below current year (1979) data and about 18% below life cycle data. Updating the model to current year data will result in a model over predicting aircraft maintenance requirements. Current year data is not representative of the last 10 years of aircraft maintenance data. Current year data or any annual data base is too unstable to warrant a complete model update every year. The model should be updated to the latest life cycle data.

The use of Maintenance Inflation Factors offers an attractive alternative to complete model update. Not only is it cost effective but using MIF's does not significantly lower the confidence level in model outputs. A screening process was used to identify those aircraft systems exhibiting abnormal maintenance inflation rates and those systems were deleted from the analysis. When the MIM computer program becomes available, MIF's can be programmed into the model and the output revised accordingly.

Vought recommends that the next complete model update be scheduled in 1981. At that time, the existing MIM data base will be five years old.

The F-8J was phased out of service in 1975. Vought recommends it be kept in the model since its maintenance data is still commensurate with its design characteristics.

Additionally, consideration should be given to dropping the AV-8A from the model. Its maintenance requirements far exceed its design characteristics. To keep the AV-8A in the data base, it will be necessary to modify AV-8A historical data to reflect a higher sortie length, one more comparable to other attack aircraft.

Other Alternatives

If the model is to be kept updated to current year data regardless of how current year data relates to life cycle data, then either current year Maintenance Inflation Factors can be used to adjust model output or a new set of index equations can be developed using current year data.

If the model is to be updated to reflect a given data base to support a new weapons system RFP, then new index equations would have to be developed.

REFERENCES

1. Kovatch, D.H. et.al., Aircraft Maintenance Experience Design Handbook, NAVAIR 00-25-402, Contract N00140-76-C-0025, Vought Corporation, Dallas, Texas. September 1979.

2. Fleet Weapon System Reliability and Maintainability Statistical Summary Tabulation, MSOD 4790.A2142-01. Navy Maintenance Support Office, Mechanicsburg, Pa. Semi-annual and quarterly reports beginning July 1970 and ending September 1979. Superceded by NAMSO 4790.A7142-01, effective July 1979.

3. Monthly 3-M Aviation Readiness Utilization Summary, MSOD 4790.A2092-01. Navy Maintenance Support Office, Mechanicsburg, Pa. Monthly reports beginning July 1970 and ending September 1979. Superceded by NAMSO 4790.A7092-01, effective August 1979.

4. Maintenance Subsystem Report, NALCOMIS-O&S (VAMOSC-AIR), Naval Air Development Center, Warminster, Pa.

5. F-18 Maintainability Prediction Report. MDC A4245-1. Contract No. N00019-75-C-0424, McDonnell Aircraft Company, St. Louis, Mo., February 1977.

APPENDIX A

AIRCRAFT ANNUAL MMH/FH DATA

FLEET RELIABILITY AND MAINTAINABILITY SUMMARY (FRAMS) REPORT 03/06/80

TABLE A-1 A-4M MMH/FH (O + I) BY CALENDAR YEAR AND AIRCRAFT STANDARD WORK UNIT CODE

SYSTEM	SWUC	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	LIFE CYCLE
AIRFRAME/FUSELAGE	11/12	I	.172	.200	.265	.393	.453	.421	.418	.454	.551	.408
LANDING GEAR	13	I	.569	.467	.840	.697	.800	.838	.816	.829	.852	.787
FLIGHT CONTROLS	14	I	.150	.159	.272	.238	.244	.308	.436	.461	.486	.347
ENGINE	23	I	.338	.304	.538	.525	.473	.528	.741	.605	.758	.594
AUXILLARY POWER PLANT	24	I	0.000	.009	.129	.192	.253	.219	.315	.320	.313	.239
POWER PLANT INSTALLATION	29	I	.037	.034	.067	.091	.111	.081	.085	.104	.157	.093
AIR CONDITIONING	41	I	.033	.069	.052	.054	.057	.047	.079	.059	.076	.061
ELECTRICAL	42	I	.109	.280	.302	.266	.411	.359	.415	.625	.650	.431
LIGHTING	44	I	.178	.110	.157	.147	.148	.212	.236	.256	.284	.206
HYDRAULIC	45	I	.021	.045	.116	.059	.058	.078	.087	.077	.074	.076
FUEL	46	I	.053	.061	.101	.125	.134	.185	.220	.241	.253	.179
OXYGEN	47	I	.012	.022	.038	.048	.064	.076	.062	.071	.078	.060
MISC UTILITIES	49	I	0.000	.004	.012	.004	.019	.011	.021	.026	.042	.018
INSTRUMENTS	51	I	.136	.222	.262	.214	.249	.267	.312	.362	.451	.299
FLIGHT REFERENCE	56	I	.051	.023	.042	.057	.051	.051	.200	.345	.436	.174
INTEG GUID/FLIGHT CONTROL	57	I	.093	.162	.189	.139	.109	.125	.149	.123	.154	.139
COMMUNICATIONS	63	I	.324	.240	.273	.295	.342	.454	.581	.507	.701	.452
NAVIGATION/WEAPONS CONTROL	71/2/3/4	I	.656	.857	1.009	.771	.808	1.136	1.211	1.263	1.356	1.083
WEAPON DELIVERY	75	I	.024	.085	.051	.097	.160	.294	.220	.246	.301	.198
ECM	76	I	0.000	.064	.063	.078	.063	.130	.190	.261	.380	.166
MISC SYSTEMS/EQUIP	90	I	.009	.015	.054	.056	.057	.032	.047	.047	.073	.047
TOTAL UNSCHEDULED	11-90	I	3.236	3.470	4.853	4.571	5.096	5.950	6.846	7.301	8.456	6.079
TOTAL AIRCRAFT	01-90	I	13.885	14.700	15.939	12.926	11.484	16.614	17.917	18.284	19.539	16.281
TOTAL FLIGHT HOURS		0.	4140.	10538.	14189.	15565.	18896.	24238.	28199.	30592.	18037.	164454.

The following notes pertain to all tables:

(1) Data source: References (2) and (3).
(2) Data prior to July 1970 not available.
(3) January 1971 through June 1971 data not available.
(4) 1979 data is through September 1979.
(5) Life Cycle is the weighted average of all available data.
(6) I = Aircraft not operational.

FLEET RELIABILITY AND MAINTAINABILITY SUMMARY (FRAMS) REPORT 03/06/80

TABLE A-2 A-6E MMH/FH (O + I) BY CALENDAR YEAR AND AIRCRAFT STANDARD WORK UNIT CODE PAGE 0

SYSTEM	SWUC	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	LIFE CYCLE
AIRFRAME/FUSELAGE	11/12	I	I	.749	1.234	1.456	1.430	1.547	2.012	1.680	2.157	1.706
LANDING GEAR	13	I	I	.711	.790	.921	1.032	1.191	1.348	1.181	1.267	1.161
FLIGHT CONTROLS	14	I	I	.377	.520	.622	.713	.969	1.180	1.117	1.134	.975
ENGINE	23	I	I	.439	.519	.691	.804	.954	1.224	1.265	1.388	1.075
AUXILLARY POWER PLANT	24	I	I	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
POWER PLANT INSTALLATION	29	I	I	.125	.156	.193	.237	.279	.442	.446	.488	.359
AIR CONDITIONING	41	I	I	.124	.159	.207	.211	.269	.329	.295	.277	.268
ELECTRICAL	42	I	I	.718	1.321	1.331	1.484	1.529	1.999	2.671	2.911	2.044
LIGHTING	44	I	I	.171	.179	.174	.172	.200	.270	.335	.418	.268
HYDRAULIC	45	I	I	.192	.222	.205	.244	.315	.395	.373	.345	.322
FUEL	46	I	I	.338	.336	.465	.479	.469	.612	.790	.785	.610
OXYGEN	47	I	I	.087	.058	.070	.082	.074	.075	.081	.099	.080
MISC UTILITIES	49	I	I	.029	.025	.045	.044	.063	.074	.064	.075	.061
INSTRUMENTS	51	I	I	.585	.613	.670	.740	.792	.866	.792	.739	.771
FLIGHT REFERENCE	56	I	I	.213	.344	.258	.226	.382	.596	.648	.691	.491
INTEG GUID/FLIGHT CONTROL	57	I	I	.142	.177	.127	.172	.230	.234	.279	.204	.229
COMMUNICATIONS	63	I	I	.362	.547	.616	1.015	.920	.931	.930	1.181	.928
NAVIGATION/WEAPONS CONTROL	71/2/3/4	I	I	4.715	5.190	4.697	4.994	5.537	6.182	6.034	6.784	5.778
WEAPON DELIVERY	75	I	I	.067	.094	.083	.130	.160	.195	.291	.245	.194
ECM	76	I	I	.546	.523	.392	.370	.487	.606	.625	.634	.579
MISC SYSTEMS/EQUIP	91	I	I	.025	.053	.033	.043	.040	.068	.064	.063	.054
TOTAL UNSCHEDULED	11-90	I	I	10.752	13.226	13.337	14.650	16.448	19.728	20.043	22.038	17.974
TOTAL AIRCRAFT	01-90	I	I	32.500	32.909	31.255	33.155	37.305	42.601	42.134	44.158	39.042
TOTAL FLIGHT HOURS		0.	0.	4142.	13771.	32196.	50775.	59876.	65755.	83427.	53372.	363314.

FLEET RELIABILITY AND MAINTAINABILITY SUMMARY (FRAMS) REPORT 03/06/80

TABLE A-3 A-7E MMH/FH (O + I) BY CALENDAR YEAR AND AIRCRAFT STANDARD WORK UNIT CODE

SYSTEM	SWUC	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	LIFE CYCLE
AIRFRAME/FUSELAGE	11/12	.538	.727	.998	1.247	1.170	1.197	1.206	1.553	1.466	1.732	1.283
LANDING GEAR	13	.426	.636	.663	.716	.899	.857	.931	.940	.916	1.057	.855
FLIGHT CONTROLS	14	.239	.362	.416	.540	.551	.513	.578	.727	.647	.674	.569
ENGINE	23	.557	.666	.932	1.077	1.600	1.276	1.207	1.177	1.157	1.254	1.161
AUXILLARY POWER PLANT	24	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
POWER PLANT INSTALLATION	29	.147	.170	.156	.213	.212	.194	.175	.212	.213	.221	.197
AIR CONDITIONING	41	.111	.157	.178	.149	.170	.171	.187	.245	.227	.293	.200
ELECTRICAL	42	.091	.151	.170	.318	.388	.364	.386	.461	.493	.601	.386
LIGHTING	44	.100	.126	.122	.131	.148	.139	.184	.195	.208	.241	.170
HYDRAULIC	45	.142	.232	.194	.183	.176	.180	.23[illegible]	.218	.191	.200	.197
FUEL	46	.079	.137	.129	.191	.254	.246	.282	.276	.282	.356	.245
OXYGEN	47	.019	.028	.036	.052	.044	.044	.035	.035	.036	.040	.038
MISC UTILITIES	49	.018	.033	.032	.034	.038	.027	.034	.040	.034	.045	.034
INSTRUMENTS	51	.243	.342	.313	.365	.347	.375	.443	.426	.430	.484	.394
FLIGHT REFERENCE	56	.116	.215	.205	.235	.278	.260	.303	.311	.313	.366	.278
INTEG GUID/FLIGHT CONTROL	57	.148	.299	.348	.426	.380	.331	.425	.484	.548	.625	.434
COMMUNICATIONS	60	.360	.403	.388	.364	.410	.448	.508	.542	.605	.682	.494
NAVIGATION/WEAPONS CONTROL	71/2/3/4	1.955	2.832	2.827	2.876	2.840	2.772	3.269	3.367	3.311	3.680	3.082
WEAPON DELIVERY	75	.226	.312	.359	.416	.429	.431	.454	.479	.450	.454	.425
ECM	76	.204	.309	.348	.260	.318	.247	.296	.317	.362	.411	.314
MISC SYSTEMS/EQUIP	90	.018	.024	.035	.027	.051	.035	.028	.030	.036	.042	.034
TOTAL UNSCHEDULED	11-90	5.735	8.206	8.369	9.832	10.721	10.127	11.178	12.104	11.948	13.517	10.820
TOTAL AIRCRAFT	01-90	17.600	21.600	25.234	25.503	25.886	25.104	27.162	28.967	29.558	33.462	27.116
TOTAL FLIGHT HOURS		37836.	34824.	76591.	89048.	87445.	104823.	110439.	128120.	134663.	91464.	895253.

FLEET RELIABILITY AND MAINTAINABILITY SUMMARY (FRAMS) REPORT 03/06/80

TABLE A-4 AV-8A MMH/FH (O + I) BY CALENDAR YEAR AND AIRCRAFT STANDARD WORK UNIT CODE

PAGE 0

SYSTEM	SWUC	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	LIFE CYCLE
AIRFRAME/FUSELAGE	11/12	I	I	.743	.595	.880	.960	1.243	1.253	1.132	1.743	1.116
LANDING GEAR	13	I	I	1.085	.952	1.219	1.257	1.203	1.387	1.206	1.251	1.223
FLIGHT CONTROLS	14	I	I	.525	.534	.733	.838	.886	.970	.824	.979	.829
ENGINE	23	I	I	.991	1.353	.931	.935	1.437	1.599	1.904	2.732	1.514
AUXILIARY POWER PLANT	24	I	I	.353	.317	.227	.252	.252	.273	.296	.366	.281
POWER PLANT INSTALLATION	29	I	I	.211	.299	.209	.380	.546	.742	.603	1.008	.535
AIR CONDITIONING	41	I	I	.147	.222	.174	.177	.200	.277	.302	.302	.233
ELECTRICAL	42	I	I	.645	.365	.928	.886	1.474	1.835	2.032	2.506	1.487
LIGHTING	44	I	I	.104	.139	.155	.129	.147	.270	.287	.381	.211
HYDRAULIC	45	I	I	.298	.201	.312	.562	.310	.458	.468	.353	.397
FUEL	46	I	I	.722	.389	.859	.533	.541	.697	.702	.833	.671
OXYGEN	47	I	I	.063	.058	.083	.131	.161	.143	.122	.186	.127
MISC UTILITIES	49	I	I	.021	.011	.015	.010	.012	.015	.031	.033	.018
INSTRUMENTS	51	I	I	.572	.495	.641	.585	.502	.648	.701	.761	.635
FLIGHT REFERENCE	56	I	I	.133	.144	.093	.206	.221	.376	.576	.574	.315
INTEG GUID/FLIGHT CONTROL	57	I	I	.124	.177	.143	.151	.271	.352	.368	.390	.265
COMMUNICATIONS	63	I	I	.990	.739	.457	.603	.733	.904	1.053	1.281	.827
NAVIGATION/WEAPONS CONTROL	71/2/3/4	I	I	4.212	3.430	2.299	2.233	1.656	2.101	1.680	1.646	2.155
WEAPON DELIVERY	75	I	I	.197	.086	.079	.150	.159	.303	.364	.362	.222
ECM	76	I	I	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MISC SYSTEMS/EQUIP	93	I	I	0.000	.014	.041	.028	.094	.049	.056	.079	.051
TOTAL UNSCHEDULED	11-93	I	I	12.180	11.187	10.512	11.045	12.248	14.775	14.820	17.865	13.183
TOTAL AIRCRAFT	01-90	I	I	24.500	21.323	25.765	27.502	28.036	36.805	34.827	37.946	30.563
TOTAL FLIGHT HOURS		0.	0.	2873.	7419.	10406.	14018.	12595.	13303.	13899.	9254.	83767.

FLEET RELIABILITY AND MAINTAINABILITY SUMMARY (FRAMS) REPORT 03/06/80

TABLE A-5 F-4J MMH/FH (O + I) BY CALENDAR YEAR AND AIRCRAFT STANDARD WORK UNIT CODE

SYSTEM	SWUC	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	LIFE CYCLE
AIRFRAME/FUSELAGE	11/12	1.035	1.263	1.487	2.055	2.716	2.673	2.699	2.645	3.055	3.139	2.307
LANDING GEAR	13	.848	1.041	1.075	1.314	1.374	1.522	1.563	1.684	1.860	1.866	1.429
FLIGHT CONTROLS	14	.652	.803	.967	1.212	1.536	1.743	1.646	1.691	1.579	1.890	1.389
ENGINE	23	1.344	1.159	.956	1.164	1.597	1.573	1.832	1.934	1.785	2.060	1.517
AUXILIARY POWER PLANT	24	0.000	0.000	0.000	0.003	0.007	0.007	0.000	0.000	0.000	0.000	0.000
POWER PLANT INSTALLATION	29	.113	.152	.152	.222	.272	.246	.322	.299	.255	.257	.233
AIR CONDITIONING	41	.287	.351	.374	.447	.529	.574	.614	.610	.631	.639	.510
ELECTRICAL	42	.295	.486	.470	.561	.807	.796	.894	.980	1.107	1.154	.766
LIGHTING	44	.124	.150	.168	.241	.252	.260	.279	.297	.327	.336	.246
HYDRAULIC	45	.266	.304	.316	.384	.516	.490	.530	.592	.734	.610	.498
FUEL	46	.358	.477	.442	.549	.780	.843	.895	.842	.804	.842	.701
OXYGEN	47	.035	.052	.054	.076	.084	.079	.074	.081	.080	.043	.069
MISC UTILITIES	49	.074	.116	.116	.189	.162	.163	.190	.183	.160	.146	.154
INSTRUMENTS	51	.265	.314	.334	.424	.514	.543	.616	.566	.657	.646	.491
FLIGHT REFERENCE	56	.389	.500	.541	.780	.839	.859	.955	.857	1.071	1.122	.797
INTEG GUID/FLIGHT CONTROL	57	.247	.279	.327	.383	.436	.422	.500	.531	.611	.724	.443
COMMUNICATIONS	63	.190	.35[illegible]	.690	1.024	1.025	1.075	1.224	1.255	1.467	1.729	1.019
NAVIGATION/WEAPONS CONTROL	71/2/3/4	3.849	4.900	5.302	5.158	6.633	5.828	6.499	7.013	7.053	6.992	6.086
WEAPON DELIVERY	75	.123	.163	.186	.305	.350	.380	.515	.558	.498	.555	.365
ECM	76	.322	.307	.519	.462	.525	.393	.532	.574	.508	.597	.481
MISC SYSTEMS/EQUIP	91	.042	.064	.091	.138	.133	.156	.183	.185	.216	.264	.147
TOTAL UNSCHEDULED	11-91	10.874	13.255	14.593	18.330	21.396	20.649	22.798	23.526	24.496	25.676	19.677
TOTAL AIRCRAFT	01-90	27.255	33.249	38.200	41.497	43.837	40.975	46.536	47.866	48.396	52.465	42.309
TOTAL FLIGHT HOURS		52634.	42019.	96825.	88737.	83398.	84352.	74043.	73567.	77239.	43049.	715915.

FLEET RELIABILITY AND MAINTAINABILITY SUMMARY (FRAMS) REPORT 03/06/80

TABLE A-6 F-4J MMH/FH (O + I) BY CALENDAR YEAR AND AIRCRAFT STANDARD WORK UNIT CODE

PAGE 0

SYSTEM	SWUC	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	LIFE CYCLE
AIRFRAME/FUSELAGE	11/12	1.121	1.855	1.773	1.317	1.702	1.397	I	I	I	I	1.638
LANDING GEAR	13	.941	1.136	1.016	1.263	1.278	1.547	I	I	I	I	1.182
FLIGHT CONTROLS	14	.626	.821	.925	1.290	1.508	1.230	I	I	I	I	1.097
ENGINE	23	1.170	.923	1.127	1.437	1.956	1.441	I	I	I	I	1.349
AUXILIARY POWER PLANT	24	0.000	0.000	0.000	0.000	0.000	0.000	I	I	I	I	0.000
POWER PLANT INSTALLATION	29	.289	.257	.269	.319	.314	.463	I	I	I	I	.314
AIR CONDITIONING	41	.201	.153	.217	.347	.410	.463	I	I	I	I	.299
ELECTRICAL	42	.582	.715	.950	1.126	1.287	1.404	I	I	I	I	1.022
LIGHTING	44	.143	.196	.189	.216	.279	.262	I	I	I	I	.213
HYDRAULIC	45	.351	.325	.368	.442	.540	.382	I	I	I	I	.405
FUEL	46	.441	.402	.368	.472	.548	.382	I	I	I	I	.434
OXYGEN	47	.031	.034	.046	.050	.057	.046	I	I	I	I	.044
MISC UTILITIES	49	.031	.023	.033	.043	.027	.011	I	I	I	I	.030
INSTRUMENTS	51	.554	.593	.717	.791	.905	.967	I	I	I	I	.759
FLIGHT REFERENCE	56	.071	.102	.131	.142	.160	.240	I	I	I	I	.141
INTEG GUID/FLIGHT CONTROL	57	.570	.713	.964	1.041	.989	1.104	I	I	I	I	.919
COMMUNICATIONS	63	.154	.796	.729	.481	.522	.657	I	I	I	I	.560
NAVIGATION/WEAPONS CONTROL	71/2/3/4	1.454	1.852	2.280	2.437	2.567	2.621	I	I	I	I	2.239
WEAPON DELIVERY	75	.173	.165	.218	.201	.322	.393	I	I	I	I	.242
ECM	76	.557	.656	1.070	.907	.466	.939	I	I	I	I	.783
MISC SYSTEMS/EQUIP	90	.021	.049	.034	.037	.052	.034	I	I	I	I	.037
TOTAL UNSCHEDULED	11-90	10.164	11.813	13.452	14.791	16.062	16.047	I	I	I	I	13.642
TOTAL AIRCRAFT	01-90	27.000	25.700	30.754	33.501	32.591	34.709	I	I	I	I	31.058
TOTAL FLIGHT HOURS		12745.	9815.	21884.	18957.	14104.	11794.	0.	0.	0.	0.	89299.

FLEET RELIABILITY AND MAINTAINABILITY SUMMARY (FRAMS) REPORT 03/06/80

TABLE A-7 F-14A MMH/FH (O + I) BY CALENDAR YEAR AND AIRCRAFT STANDARD WORK UNIT CODE PAGE 0

SYSTEM	SWUC	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	LIFE CYCLE
AIRFRAME/FUSELAGE	11/12	I	I	I	4.193	2.053	2.424	2.568	3.521	3.968	4.006	3.347
LANDING GEAR	13	I	I	I	1.976	1.151	1.514	1.564	1.455	1.497	1.431	1.471
FLIGHT CONTROLS	14	I	I	I	3.064	1.762	2.276	2.552	2.460	2.641	2.524	2.471
ENGINE	23	I	I	I	3.636	1.886	4.223	3.112	2.449	2.073	2.657	2.664
AUXILLARY POWER PLANT	24	I	I	I	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
POWER PLANT INSTALLATION	29	I	I	I	1.734	1.295	1.431	1.441	1.335	1.309	1.386	1.368
AIR CONDITIONING	41	I	I	I	1.108	.691	.816	.587	.564	.711	.559	.649
ELECTRICAL	42	I	I	I	.351	.439	.799	.971	1.150	1.397	1.336	1.115
LIGHTING	44	I	I	I	.496	.378	.379	.377	.342	.403	.374	.378
HYDRAULIC	45	I	I	I	1.121	.613	.678	.710	.626	.560	.614	.633
FUEL	46	I	I	I	2.776	1.140	.779	.804	.766	.841	.693	.836
OXYGEN	47	I	I	I	.075	.046	.070	.051	.048	.053	.067	.056
MISC UTILITIES	49	I	I	I	.088	.089	.079	.082	.082	.144	.119	.105
INSTRUMENTS	51	I	I	I	1.179	1.063	1.131	1.145	1.034	1.058	1.036	1.073
FLIGHT REFERENCE	56	I	I	I	2.133	1.251	1.443	1.302	.905	1.077	1.153	1.159
INTEG GUID/FLIGHT CONTROL	57	I	I	I	.339	.418	.506	.654	.665	.849	.906	.713
COMMUNICATIONS	60	I	I	I	1.663	1.446	1.559	1.656	1.474	1.579	1.786	1.595
NAVIGATION/WEAPONS CONTROL	71/2/3/4	I	I	I	8.732	5.384	5.665	5.058	4.755	5.455	6.146	5.428
WEAPON DELIVERY	75	I	I	I	.530	.500	.852	.732	.635	.698	.636	.679
ECM	76	I	I	I	.082	.456	.555	.845	.816	.751	.698	.719
MISC SYSTEMS/EQUIP	90	I	I	I	.055	.041	.077	.050	.066	.092	.104	.076
TOTAL UNSCHEDULED	11-91	I	I	I	35.597	22.191	27.353	26.318	25.207	27.206	28.311	26.601
TOTAL AIRCRAFT	01-90	I	I	I	54.948	40.180	59.348	54.394	54.570	53.797	57.819	54.504
TOTAL FLIGHT HOURS		0.	0.	0.	3079.	16261.	23710.	36754.	45637.	57091.	38441.	220973.

TABLE A-8 S-3A MMH/FH (O + I) BY CALENDAR YEAR AND AIRCRAFT STANDARD WORK UNIT CODE

SYSTEM	SWUC	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	LIFE CYCLE
AIRFRAME/FUSELAGE	11/12	I	I	I	I	.970	1.000	1.016	1.172	1.715	1.746	1.354
LANDING GEAR	13	I	I	I	I	2.062	1.358	1.235	1.048	1.314	1.150	1.232
FLIGHT CONTROLS	14	I	I	I	I	1.163	1.431	.908	.990	1.099	1.196	1.084
ENGINE	23	I	I	I	I	.551	1.139	.766	.903	1.383	1.221	1.071
AUXILLARY POWER PLANT	24	I	I	I	I	.462	.339	.276	.270	.200	.227	.258
POWER PLANT INSTALLATION	29	I	I	I	I	.191	.287	.227	.279	.401	.469	.330
AIR CONDITIONING	41	I	I	I	I	.421	.492	.432	.379	.395	.477	.421
ELECTRICAL	42	I	I	I	I	.652	.591	.470	.428	.556	.702	.536
LIGHTING	44	I	I	I	I	.341	.247	.222	.240	.228	.240	.237
HYDRAULIC	45	I	I	I	I	.172	.178	.159	.194	.232	.191	.195
FUEL	46	I	I	I	I	.238	.169	.169	.216	.202	.201	.197
OXYGEN	47	I	I	I	I	.052	.056	.039	.029	.038	.056	.041
MISC UTILITIES	49	I	I	I	I	.071	.060	.049	.037	.056	.070	.053
INSTRUMENTS	51	I	I	I	I	.585	.441	.318	.276	.288	.267	.311
FLIGHT REFERENCE	53	I	I	I	I	.225	.304	.212	.261	.261	.298	.260
INTEG GUID/FLIGHT CONTROL	57	I	I	I	I	.329	.508	.514	.458	.517	.607	.509
COMMUNICATIONS	63	I	I	I	I	.973	1.073	1.067	1.109	1.332	1.409	1.200
NAVIGATION/WEAPONS CONTROL	71/2/3/4	I	I	I	I	5.016	4.714	4.485	4.498	5.110	5.609	4.870
WEAPON DELIVERY	75	I	I	I	I	.023	.067	.112	.102	.150	.129	.115
ECM	76	I	I	I	I	.115	.134	.156	.136	.172	.188	.157
MISC SYSTEMS/EQUIP	90	I	I	I	I	.198	.189	.131	.206	.171	.241	.183
TOTAL UNSCHEDULED	11-93	I	I	I	I	15.183	15.231	13.551	13.737	16.378	17.306	15.158
TOTAL AIRCRAFT	01-90	I	I	I	I	29.572	35.326	28.840	28.666	34.147	37.311	32.205
TOTAL FLIGHT HOURS		0.	0.	0.	0.	6812.	22562.	44027.	58400.	61438.	35819.	229058.

APPENDIX B

AIRCRAFT ANNUAL MA/FH DATA

FLEET RELIABILITY AND MAINTAINABILITY SUMMARY (FRAMS) REPORT 03/06/80

TABLE B-1 A-4M MA/FH BY CALENDAR YEAR AND AIRCRAFT STANDARD WORK UNIT CODE

SYSTEM	SWUC	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	LIFE CYCLE
AIRFRAME/FUSELAGE	11/12	I	.041	.054	.065	.084	.107	.098	.136	.125	.147	.107
LANDING GEAR	13	I	.179	.192	.211	.203	.195	.184	.190	.180	.202	.192
FLIGHT CONTROLS	14	I	.039	.039	.055	.034	.058	.073	.102	.088	.094	.073
ENGINE	23	I	.017	.056	.055	.057	.060	.058	.065	.069	.081	.062
AUXILLARY POWER PLANT	24	I	0.000	.003	.018	.036	.059	.052	.055	.060	.043	.047
POWER PLANT INSTALLATION	29	I	.009	.017	.021	.025	.033	.023	.023	.025	.030	.025
AIR CONDITIONING	41	I	.011	.016	.018	.019	.024	.015	.021	.019	.019	.019
ELECTRICAL	42	I	.038	.057	.069	.064	.093	.076	.080	.101	.101	.082
LIGHTING	44	I	.065	.067	.061	.061	.062	.071	.086	.075	.066	.070
HYDRAULIC	45	I	.011	.013	.021	.017	.016	.015	.020	.015	.014	.016
FUEL	46	I	.016	.029	.024	.031	.038	.043	.052	.042	.044	.040
OXYGEN	47	I	.008	.014	.015	.015	.022	.018	.017	.017	.012	.017
MISC UTILITIES	49	I	0.000	.001	.003	.002	.003	.002	.005	.009	.009	.005
INSTRUMENTS	51	I	.051	.059	.067	.065	.085	.052	.077	.074	.087	.072
FLIGHT REFERENCE	56	I	.018	.012	.013	.012	.015	.013	.033	.038	.035	.024
INTEG GUID/FLIGHT CONTROL	57	I	.018	.026	.027	.021	.021	.017	.021	.017	.018	.020
COMMUNICATIONS	63	I	.066	.087	.083	.091	.100	.095	.131	.120	.118	.106
NAVIGATION/WEAPONS CONTROL	71/2/3/4	I	.173	.240	.223	.134	.196	.186	.219	.206	.176	.203
WEAPON DELIVERY	75	I	.010	.036	.030	.037	.048	.077	.082	.087	.092	.066
ECM	76	I	0.000	.016	.014	.023	.018	.022	.036	.042	.041	.028
MISC SYSTEMS/EQUIP	93	I	.004	.014	.030	.027	.040	.024	.029	.031	.027	.028
TOTAL UNSCHEDULED	11-93	I	.786	1.053	1.127	1.152	1.302	1.231	1.495	1.446	1.459	1.310
TOTAL FLIGHT HOURS		0.	4140.	10538.	14139.	15565.	18896.	24298.	28199.	33592.	18037.	164454.

The following notes pertain to all tables:

(1) Data source: References (2) and (3).
(2) Data prior to July 1970 not available.
(3) January 1971 through June 1971 data not available.
(4) 1979 data is through September 1979.
(5) Life Cycle is the weighted average of all available data.
(6) I = Aircraft not operational.

FLEET RELIABILITY AND MAINTAINABILITY SUMMARY (FRAMS) REPORT 03/06/80

TABLE B-2 A-6E MA/FH BY CALENDAR YEAR AND AIRCRAFT STANDARD WORK UNIT CODE

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SYSTEM	SWUC	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	LIFE CYCLE
AIRFRAME/FUSELAGE	11/12	I	I	.227	.339	.342	.360	.388	.451	.415	.420	.399
LANDING GEAR	13	I	I	.179	.191	.194	.211	.210	.224	.203	.201	.207
FLIGHT CONTROLS	14	I	I	.056	.079	.080	.092	.117	.127	.125	.109	.111
ENGINE	23	I	I	.072	.086	.064	.081	.097	.115	.122	.131	.105
AUXILIARY POWER PLANT	24	I	I	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
POWER PLANT INSTALLATION	29	I	I	.032	.045	.034	.043	.047	.067	.074	.070	.058
AIR CONDITIONING	41	I	I	.050	.063	.058	.051	.069	.075	.066	.055	.065
ELECTRICAL	42	I	I	.141	.271	.255	.264	.271	.314	.348	.319	.299
LIGHTING	44	I	I	.077	.100	.090	.085	.084	.095	.097	.106	.093
HYDRAULIC	45	I	I	.047	.042	.040	.046	.053	.061	.054	.044	.051
FUEL	46	I	I	.052	.078	.081	.081	.092	.099	.103	.106	.094
OXYGEN	47	I	I	.035	.035	.029	.029	.028	.029	.027	.023	.028
MISC UTILITIES	49	I	I	.010	.009	.012	.013	.013	.017	.014	.014	.014
INSTRUMENTS	51	I	I	.203	.236	.196	.20[illegible]	.202	.237	.175	.139	.188
FLIGHT REFERENCE	56	I	I	.051	.085	.076	.062	.084	.117	.111	.097	.094
INTEG GUID/FLIGHT CONTROL	57	I	I	.021	.035	.026	.029	.037	.040	.034	.021	.032
COMMUNICATIONS	60	I	I	.153	.202	.179	.218	.221	.192	.188	.174	.196
NAVIGATION/WEAPONS CONTROL	71/2/3/4	I	I	.570	.929	.829	.766	.816	.832	.752	.668	.761
WEAPON DELIVERY	75	I	I	.027	.050	.033	.044	.053	.063	.063	.065	.055
ECM	76	I	I	.100	.098	.076	.063	.072	.080	.084	.071	.076
MISC SYSTEMS/EQUIP	91	I	I	.025	.032	.021	.026	.027	.032	.039	.030	.029
TOTAL UNSCHEDULED	11-91	I	I	2.441	3.112	2.727	2.780	2.997	3.245	3.092	2.881	2.987
TOTAL FLIGHT HOURS		0.	0.	4142.	13771.	32196.	50775.	59876.	55755.	83427.	53372.	363314.

FLEET RELIABILITY AND MAINTAINABILITY SUMMARY (FRAMS) REPORT 03/06/80

TABLE B-3 A-7E MA/FH BY CALENDAR YEAR AND AIRCRAFT STANDARD WORK UNIT CODE

SYSTEM	SWUC	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	LIFE CYCLE
AIRFRAME/FUSELAGE	11/12	.133	.176	.166	.189	.243	.238	.269	.353	.375	.394	.277
LANDING GEAR	13	.141	.163	.174	.187	.215	.200	.202	.218	.210	.209	.200
FLIGHT CONTROLS	14	.047	.059	.059	.075	.080	.073	.080	.097	.089	.080	.078
ENGINE	23	.053	.057	.056	.065	.082	.062	.064	.069	.081	.081	.069
AUXILLARY POWER PLANT	24	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
POWER PLANT INSTALLATION	29	.055	.053	.045	.051	.054	.045	.041	.045	.048	.047	.047
AIR CONDITIONING	41	.045	.050	.050	.041	.044	.037	.040	.049	.048	.053	.045
ELECTRICAL	42	.029	.037	.034	.049	.059	.054	.063	.079	.083	.089	.063
LIGHTING	44	.064	.068	.060	.050	.067	.058	.067	.073	.073	.079	.068
HYDRAULIC	45	.058	.078	.059	.056	.056	.051	.056	.049	.041	.038	.051
FUEL	46	.018	.029	.021	.027	.034	.034	.037	.037	.042	.044	.034
OXYGEN	47	.014	.017	.015	.020	.018	.016	.014	.015	.014	.014	.016
MISC UTILITIES	49	.007	.011	.008	.008	.007	.006	.007	.007	.006	.006	.007
INSTRUMENTS	51	.100	.114	.098	.098	.111	.096	.111	.117	.114	.108	.107
FLIGHT REFERENCE	56	.053	.077	.067	.067	.077	.069	.076	.078	.074	.071	.073
INTEG GUID/FLIGHT CONTROL	57	.050	.073	.080	.084	.080	.065	.075	.087	.087	.085	.079
COMMUNICATIONS	60	.127	.160	.135	.127	.149	.126	.145	.149	.144	.140	.140
NAVIGATION/WEAPONS CONTROL	71/2/3/4	.746	.773	.634	.593	.582	.484	.556	.587	.537	.588	.574
WEAPON DELIVERY	75	.094	.105	.116	.113	.116	.107	.128	.131	.114	.121	.117
ECM	76	.055	.059	.077	.057	.063	.044	.050	.051	.057	.059	.056
MISC SYSTEMS/EQUIP	90	.010	.015	.021	.016	.025	.017	.016	.016	.020	.021	.018
TOTAL UNSCHEDULED	11-90	1.923	2.199	1.379	1.989	2.168	1.886	2.104	2.311	2.261	2.253	2.127
TOTAL FLIGHT HOURS		37836.	34824.	76591.	89048.	87445.	104823.	110439.	128120.	134663.	91464.	895253.

FLEET RELIABILITY AND MAINTAINABILITY SUMMARY (FRAMS) REPORT 03/06/80

TABLE B-4 AV-8A MA/FH BY CALENDAR YEAR AND AIRCRAFT STANDARD WORK UNIT CODE

SYSTEM	SWUC	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	LIFE CYCLE
AIRFRAME/FUSELAGE	11/12	I	I	.166	.166	.186	.206	.238	.255	.276	.320	.235
LANDING GEAR	13	I	I	.284	.218	.229	.193	.222	.260	.229	.238	.229
FLIGHT CONTROLS	14	I	I	.095	.098	.116	.117	.119	.153	.118	.119	.121
ENGINE	23	I	I	.097	.068	.064	.063	.099	.128	.125	.149	.100
AUXILLARY POWER PLANT	24	I	I	.068	.061	.041	.041	.045	.043	.042	.053	.046
POWER PLANT INSTALLATION	29	I	I	.085	.081	.052	.072	.120	.152	.116	.173	.110
AIR CONDITIONING	41	I	I	.058	.059	.040	.039	.042	.052	.055	.055	.048
ELECTRICAL	42	I	I	.286	.322	.304	.289	.333	.474	.475	.349	.367
LIGHTING	44	I	I	.079	.074	.077	.064	.069	.096	.088	.106	.081
HYDRAULIC	45	I	I	.099	.055	.066	.075	.051	.073	.069	.061	.067
FUEL	46	I	I	.081	.078	.117	.111	.113	.144	.130	.145	.120
OXYGEN	47	I	I	.039	.028	.030	.028	.033	.025	.018	.021	.026
MISC UTILITIES	49	I	I	.011	.009	.011	.003	.003	.002	.004	.004	.005
INSTRUMENTS	51	I	I	.235	.190	.166	.160	.163	.179	.151	.167	.169
FLIGHT REFERENCE	56	I	I	.034	.018	.015	.022	.041	.065	.068	.074	.044
INTEG GUID/FLIGHT CONTROL	57	I	I	.018	.044	.026	.023	.047	.054	.042	.041	.039
COMMUNICATIONS	60	I	I	.236	.155	.121	.129	.130	.153	.143	.167	.144
NAVIGATION/WEAPONS CONTROL	71/2/3/4	I	I	.645	.514	.321	.344	.313	.308	.223	.246	.325
WEAPON DELIVERY	75	I	I	.063	.036	.040	.059	.036	.071	.083	.118	.064
ECM	76	I	I	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MISC SYSTEMS/EQUIP	90	I	I	0.000	.005	.013	.007	.027	.015	.020	.022	.015
TOTAL UNSCHEDULED	11-90	I	I	2.699	2.284	2.058	2.054	2.257	2.719	2.498	2.650	2.373
TOTAL FLIGHT HOURS		0.	0.	2873.	7419.	10406.	14018.	12595.	13303.	13899.	9254.	83767.

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TABLE B-5 F-4J MA/FH BY CALENDAR YEAR AND AIRCRAFT STANDARD WORK UNIT CODE

SYSTEM	SWUC	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	LIFE CYCLE
AIRFRAME/FUSELAGE	11/12	.253	.313	.361	.439	.490	.533	.574	.563	.620	.672	.485
LANDING GEAR	13	.211	.229	.246	.282	.280	.292	.304	.293	.308	.326	.278
FLIGHT CONTROLS	14	.096	.102	.126	.155	.175	.190	.194	.190	.183	.190	.162
ENGINE	23	.067	.079	.073	.093	.124	.142	.136	.128	.123	.127	.112
AUXILLARY POWER PLANT	24	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
POWER PLANT INSTALLATION	29	.022	.025	.025	.036	.042	.039	.044	.038	.036	.035	.035
AIR CONDITIONING	41	.051	.061	.061	.072	.081	.083	.085	.080	.080	.074	.074
ELECTRICAL	42	.068	.087	.079	.093	.114	.113	.116	.118	.123	.118	.103
LIGHTING	44	.071	.077	.078	.103	.104	.108	.109	.107	.110	.112	.099
HYDRAULIC	45	.052	.051	.045	.057	.066	.066	.077	.080	.086	.069	.065
FUEL	45	.058	.063	.063	.076	.087	.090	.094	.094	.088	.087	.081
OXYGEN	47	.023	.025	.024	.032	.037	.035	.034	.032	.023	.014	.029
MISC UTILITIES	49	.011	.013	.013	.017	.019	.020	.021	.021	.021	.018	.018
INSTRUMENTS	51	.109	.104	.096	.113	.125	.129	.134	.129	.125	.113	.118
FLIGHT REFERENCE	55	.090	.095	.097	.125	.139	.142	.144	.130	.135	.113	.123
INTEG GUID/FLIGHT CONTROL	57	.044	.044	.050	.060	.062	.063	.073	.071	.072	.072	.062
COMMUNICATIONS	63	.068	.091	.189	.267	.285	.278	.298	.287	.279	.260	.241
NAVIGATION/WEAPONS CONTROL	71/2/3/4	.882	.973	.915	.977	1.023	.955	.933	.955	.936	.822	.944
WEAPON DELIVERY	75	.053	.058	.075	.103	.113	.123	.157	.168	.154	.182	.120
ECM	76	.056	.059	.086	.076	.078	.063	.074	.081	.079	.082	.075
MISC SYSTEMS/EQUIP	90	.028	.031	.052	.078	.082	.081	.105	.099	.109	.129	.080
TOTAL UNSCHEDULED	11-90	2.329	2.588	2.761	3.262	3.536	3.551	3.725	3.674	3.699	3.628	3.311
TOTAL FLIGHT HOURS		52694.	42019.	96825.	58737.	83390.	84352.	74043.	73567.	77239.	43049.	715915.

FLEET RELIABILITY AND MAINTAINABILITY SUMMARY (FRAMS) REPORT 03/06/80

TABLE B-6 F-4J MA/FH BY CALENDAR YEAR AND AIRCRAFT STANDARD WORK UNIT CODE

PAGE 0

SYSTEM	SWUC	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	LIFE CYCLE
AIRFRAME/FUSELAGE	11/12	.148	.177	.232	.311	.396	.300	I	I	I	I	.266
LANDING GEAR	13	.232	.246	.241	.296	.317	.309	I	I	I	I	.273
FLIGHT CONTROLS	14	.083	.100	.127	.165	.215	.157	I	I	I	I	.144
ENGINE	23	.063	.067	.079	.093	.119	.095	I	I	I	I	.087
AUXILLARY POWER PLANT	24	0.000	0.000	0.000	0.000	0.000	0.000	I	I	I	I	0.000
POWER PLANT INSTALLATION	29	.074	.071	.066	.084	.088	.112	I	I	I	I	.081
AIR CONDITIONING	41	.043	.040	.047	.080	.085	.076	I	I	I	I	.063
ELECTRICAL	42	.086	.088	.101	.154	.172	.169	I	I	I	I	.129
LIGHTING	44	.079	.092	.080	.099	.132	.124	I	I	I	I	.099
HYDRAULIC	45	.063	.061	.075	.097	.116	.091	I	I	I	I	.085
FUEL	46	.053	.048	.054	.068	.076	.061	I	I	I	I	.061
OXYGEN	47	.016	.014	.014	.020	.024	.018	I	I	I	I	.018
MISC UTILITIES	49	.004	.004	.004	.006	.005	.003	I	I	I	I	.004
INSTRUMENTS	51	.154	.175	.163	.229	.267	.258	I	I	I	I	.207
FLIGHT REFERENCE	56	.028	.039	.038	.048	.060	.074	I	I	I	I	.047
INTEG GUID/FLIGHT CONTROL	57	.122	.125	.136	.172	.184	.190	I	I	I	I	.155
COMMUNICATIONS	63	.072	.218	.175	.157	.168	.167	I	I	I	I	.158
NAVIGATION/WEAPONS CONTROL	71/2/3/4	.348	.389	.390	.433	.484	.430	I	I	I	I	.413
WEAPON DELIVERY	75	.075	.055	.078	.068	.081	.076	I	I	I	I	.073
ECM	76	.136	.124	.145	.107	.071	.138	I	I	I	I	.121
MISC SYSTEMS/EQUIP	93	.011	.013	.011	.019	.021	.016	I	I	I	I	.015
TOTAL UNSCHEDULED	11-30	2.031	2.142	2.274	2.712	3.100	2.883	I	I	I	I	2.529
TOTAL FLIGHT HOURS		12745.	9815.	21854.	18957.	14104.	11794.	0.	0.	0.	0.	89299.

FLEET RELIABILITY AND MAINTAINABILITY SUMMARY (FRAMS) REPORT 03/06/80

TABLE B-7 F-14 MA/FH BY CALENDAR YEAR AND AIRCRAFT STANDARD WORK UNIT CODE

SYSTEM	SWUC	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	LIFE CYCLE
AIRFRAME/FUSELAGE	11/12	I	I	I	.519	.363	.460	.463	.553	.632	.829	.583
LANDING GEAR	13	I	I	I	.303	.207	.251	.279	.270	.259	.245	.258
FLIGHT CONTROLS	14	I	I	I	.206	.144	.164	.179	.195	.202	.205	.189
ENGINE	23	I	I	I	.192	.114	.152	.149	.139	.114	.132	.133
AUXILLARY POWER PLANT	24	I	I	I	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
POWER PLANT INSTALLATION	29	I	I	I	.193	.201	.227	.234	.222	.190	.175	.206
AIR CONDITIONING	41	I	I	I	.103	.082	.119	.098	.099	.106	.096	.101
ELECTRICAL	42	I	I	I	.150	.049	.108	.134	.151	.156	.149	.136
LIGHTING	44	I	I	I	.185	.150	.150	.117	.117	.144	.124	.132
HYDRAULIC	45	I	I	I	.142	.082	.086	.079	.079	.067	.064	.075
FUEL	46	I	I	I	.159	.102	.085	.077	.068	.072	.055	.074
OXYGEN	47	I	I	I	.029	.018	.024	.023	.020	.018	.020	.020
MISC UTILITIES	49	I	I	I	.022	.014	.016	.014	.011	.020	.017	.016
INSTRUMENTS	51	I	I	I	.162	.175	.193	.190	.186	.203	.172	.188
FLIGHT REFERENCE	55	I	I	I	.239	.236	.257	.216	.152	.168	.150	.187
INTEG GUID/FLIGHT CONTROL	57	I	I	I	.039	.062	.069	.080	.088	.098	.084	.084
COMMUNICATIONS	60	I	I	I	.313	.395	.382	.378	.360	.341	.295	.351
NAVIGATION/WEAPONS CONTROL	71/2/3/4	I	I	I	.970	.954	.950	.771	.716	.721	.713	.772
WEAPON DELIVERY	75	I	I	I	.085	.078	.142	.175	.143	.132	.131	.138
ECM	76	I	I	I	.012	.070	.090	.094	.089	.074	.067	.080
MISC SYSTEMS/EQUIP	91	I	I	I	.039	.024	.042	.040	.043	.054	.054	.046
TOTAL UNSCHEDULED	11-90	I	I	I	4.110	3.532	3.985	3.800	3.725	3.786	3.796	3.785
TOTAL FLIGHT HOURS		0.	0.	0.	3079.	16261.	23718.	36754.	45637.	57091.	38441.	220973.

FLEET RELIABILITY AND MAINTAINABILITY SUMMARY (FRAMS) REPORT 03/06/80

TABLE B-8 S-3A MA/FH BY CALENDAR YEAR AND AIRCRAFT STANDARD WORK UNIT CODE

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SYSTEM	SWUC	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	LIFE CYCLE
AIRFRAME/FUSELAGE	11/12	I	I	I	I	.204	.257	.239	.274	.372	.332	.299
LANDING GEAR	13	I	I	I	I	.337	.315	.271	.251	.253	.200	.256
FLIGHT CONTROLS	14	I	I	I	I	.140	.184	.140	.147	.156	.134	.150
ENGINE	23	I	I	I	I	.086	.10[illegible]	.068	.074	.098	.087	.[illegible]64
AUXILLARY POWER PLANT	24	I	I	I	I	.030	.091	.064	.059	.040	.029	.054
POWER PLANT INSTALLATION	29	I	I	I	I	.050	.079	.063	.081	.101	.09[illegible]	.083
AIR CONDITIONING	41	I	I	I	I	.073	.096	.108	.096	.096	.096	.098
ELECTRICAL	42	I	I	I	I	.095	.111	.094	.081	.099	.101	.095
LIGHTING	44	I	I	I	I	.116	.086	.081	.080	.079	.069	.080
HYDRAULIC	45	I	I	I	I	.036	.038	.035	.038	.040	.027	.036
FUEL	46	I	I	I	I	.042	.033	.029	.035	.032	.033	.033
OXYGEN	47	I	I	I	I	.016	.017	.015	.012	.013	.014	.014
MISC UTILITIES	49	I	I	I	I	.011	.011	.006	.017	.009	.007	.008
INSTRUMENTS	51	I	I	I	I	.126	.150	.114	.096	.088	.069	.099
FLIGHT REFERENCE	55	I	I	I	I	.051	.075	.052	.077	.066	.051	.066
INTEG GUID/FLIGHT CONTROL	57	I	I	I	I	.052	.094	.108	.103	.103	.083	.099
COMMUNICATIONS	63	I	I	I	I	.265	.289	.263	.275	.275	.250	.270
NAVIGATION/WEAPONS CONTROL	71/2/3/4	I	I	I	I	.903	.981	.885	.906	.852	.750	.870
WEAPON DELIVERY	75	I	I	I	I	.008	.020	.026	.024	.040	.034	.029
ECM	76	I	I	I	I	.025	.032	.033	.022	.024	.022	.026
MISC SYSTEMS/EQUIP	93	I	I	I	I	.066	.128	.075	.075	.075	.076	.080
TOTAL UNSCHEDULED	11-98	I	I	I	I	2.860	3.260	2.852	2.880	2.943	2.610	2.886
TOTAL FLIGHT HOURS		0.	0.	0.	0.	6812.	22562.	44027.	58400.	61438.	35819.	229858.

LIST OF ABBREVIATIONS AND ACRONYMS

ADP	Automatic Data Processing
AMED	Aircraft Maintenance Experience Design
ASW	Anti-Submarine Warfare
CLASS 1	Customer Reported Gross Maintenance
CLASS 3	Contractor Controllable Design Maintenance
CYD	Current Year Data
FI	Frequency Index
FIDR	Frequency Index Defect Ratio
FIIR	Frequency Index I-Level Ratio
FRAMS	Fleet Reliability and Maintainability Summary
GSE	Ground Support Equipment
I-Level	Intermediate Level
JCN	Job Control Number
LCD	Life Cycle Data
M	Maintainability
MA/FH	Maintenance Action per Flight Hour
MEN	Men per Maintenance Action
MI	Maintenance Index
MIDR	Maintenance Index Defect Ratio
MIF	Maintenance Inflation Factor
MIIR	Maintenance Index I-Level Ratio

LIST OF ABBREVIATIONS AND ACRONYMS (Continued)

MIM	Maintainability Index Model
MMH/FH	Maintenance Manhour per Flight Hour
MSOD	Maintenance Support Office Department
MTTR	Mean Time To Repair
NADC	Naval Air Development Center
NALCOMIS	Naval Aviation Logistics Command Management Information System
NAMSO	Navy Maintenance Support Office
NAVAIR	Naval Air Systems Command
O-Level	Organizational Level
P	Removed
Q	Installed
SCH MAF	Scheduled Maintenance Action Form
SCH SAF	Scheduled Support Action Form
SWUC	Standard Work Unit Code
T	Removed for Cannibalization
T/M/S	Type Model Series
U	Installed for Cannibalization
UNSCH SAF	Unscheduled Support Action Form
VMAX	Maximum Speed at Altitude

LIST OF ABBREVIATIONS AND ACRONYMS (Continued)

WTMT	Weight Empty
WUC	Work Unit Code
3-M	Maintenance Material Management System